Table of Contents

List of Figures

List of Tables

1 Purpose and Scope

2 ASA System Requirements

3 Interface And Subsystem Requirements

ASA subsystems, as described in Chapter 2, and as depicted in Figure 3.0-1, consist of surveillance transmit and receive functions, Surveillance Transmit Processing (STP), Airborne Surveillance and Separation Assurance Processing (ASSAP), and the Cockpit Display of Traffic Information (CDTI). In addition, ASA interfaces with several external subsystems, including navigation, and potentially, the FMS and flight controls.

This chapter details interface requirements between ASA subsystems, and details specific subsystem requirements. This chapter also documents assumptions on the performance of subsystems external to ASA.

The chapter is structured so that ASA transmit functions and ASA receive functions are treated separately. Both transmit and receive function requirements are broken into one section that describes interfaces and a section that describes functional and performance requirements.

ASA requires interfaces to and from many existing and envisioned on-board avionics systems. All interface requirements depicted in Figure 3.0-1 relevant to ASA are detailed in the descriptions and tables below.

Note that Figure 3.0-1 identifies system interfaces that are outside of ASA. It is also noted in the figure that some interfaces in the figure from ASA are not specified in this version of the ASA MASPS, but will be specified in later versions. Some of these interfaces are described in the “probe” application analyses as potential future requirements.

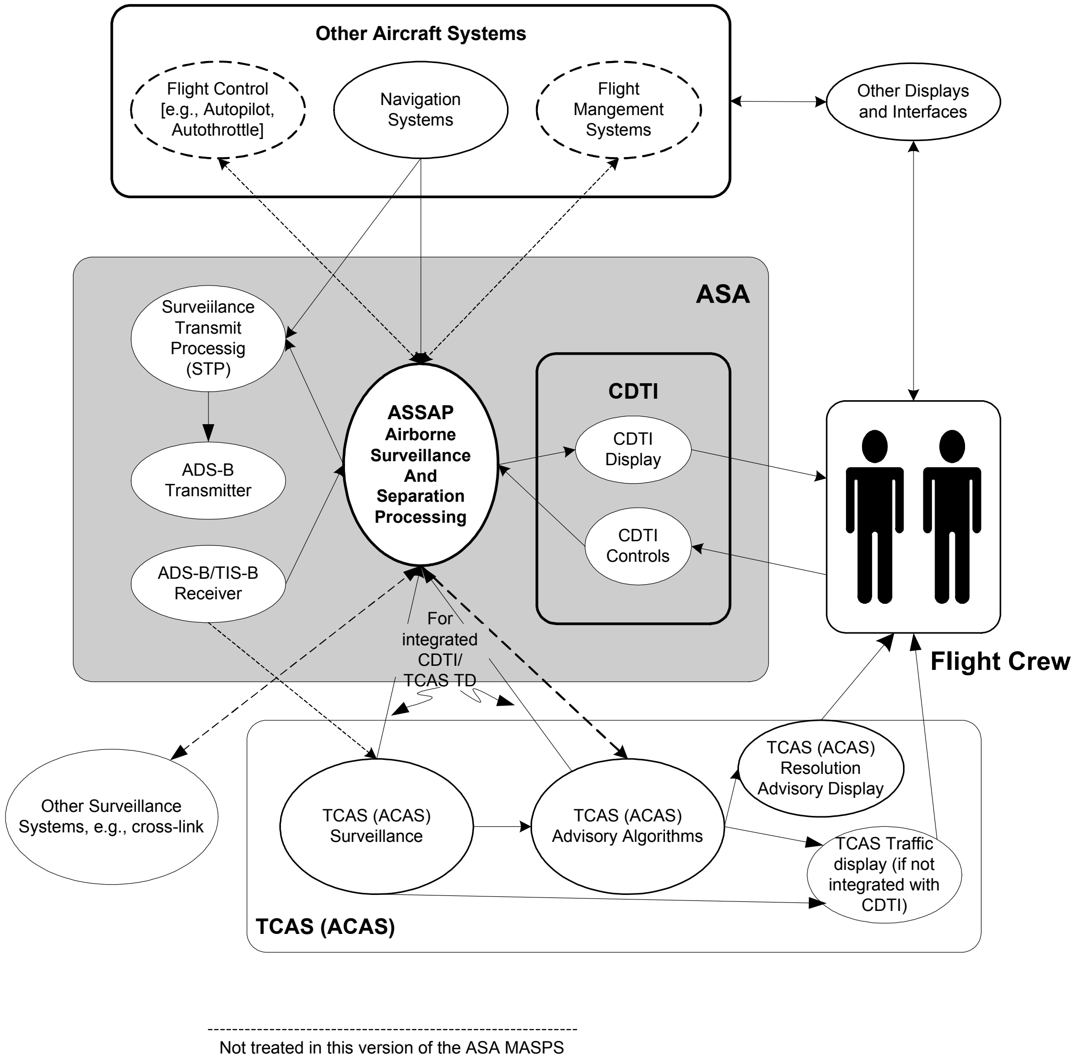

Figure 3.0-1: ASA Subsystems And Their Interfaces

3.1 ASA Transmitting Participant Subsystems

The ASA Transmit Subsystem, represented by interfaces B to D in Figure 3-1, **shall** consist of a Surveillance Transmit Processing subsystem (STP) and an ADS-B Transmitting subsystem. These subsystems take data from on-board aircraft sensors and systems, convert to defined ADS-B data standards and provide for broadcast of this ADS-B data to other aircraft and ground users to support surveillance applications.

Note: *The ADS-B data standards are defined in the ADS-B MASPS document. The ADS-B MASPS does not define the on-board data conversion processing requirements, but only data definition and format requirements. In some ADS-B equipment architectures, the ADS-B data sources may directly interface with the ADS-B transmitting equipment where both functions are provided and not require external pre-processing of surveillance data.*

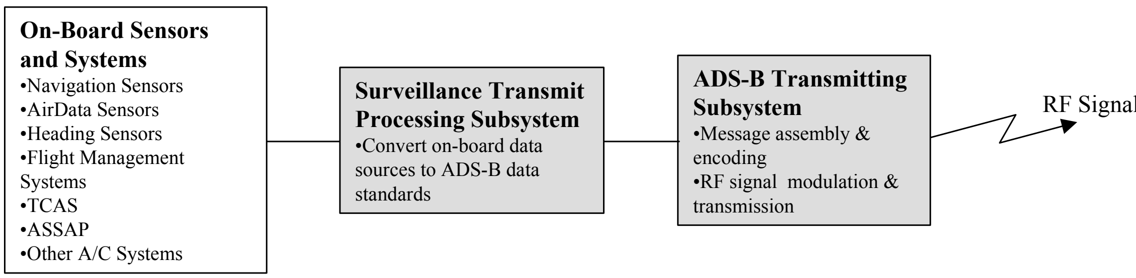

Figure 3.1-1: ASA Transmit Subsystems

3.1.1 Surveillance Transmit Processing (STP) Subsystem Requirements

The Surveillance Transmit Processing (STP) subsystem, represented by interfaces B to C in Figure 3-1, **shall** provide for the conversion and formatting of surveillance data obtained from aircraft sensors and systems into the standardized ADS-B formats that are broadcast to other users. Because there will not be uniformity in the data interfaces of avionics equipment on-board ASA equipped aircraft, the source data may require conversion to comply with the standard ADS-B data definitions. Some of the surveillance information elements that require specific processing are:

- Determination of Transmit Quality Level
- Determination of own aircraft Application Capability Level
- Determination of navigation data quality
- Determination of common position reference
- Management of multiple navigation data sources
- Determination of air/ground state
- Determination of flight path intent (future function)

Note: *Additional items requiring specific processing to achieve a standardized information exchange definition may be added in the future as they are identified. One item to be added in future versions of this MASPS is the determination of aircraft intent.*

3.1.1.1 ASA Transmit Subsystem Transmit Quality Levels

The "transmit quality level" broadcast by the on-board ASA Transmit subsystem indicates the quality of the transmitted surveillance information, which when used with other data quality parameters, e.g. NIC, NAC, SIL, etc., allow users to assess the suitability of the received surveillance information to support a user application. The transmit quality level value sent identifies the quality of both the surveillance equipment on-board the aircraft and the surveillance information transmitted. Transmit quality levels "group" sets of requirements for surveillance equipment and transmitted surveillance information. Transmit Quality levels are hierarchical in that higher transmit quality levels announce that a participant supports the capabilities of all lower transmit quality levels.

All ASA Transmit subsystem equipped aircraft **shall** assess and transmit their transmit quality level. The transmit quality level **shall** be assessed dynamically, so that changes in capabilities are announced, especially when the on-board equipment no longer qualifies for its previously announced transmit quality level.

Transmit Quality level conveys quality characteristics of the on-board ASA Transmit subsystem that are not specifically communicated in other ADS-B messages, such as the actual NAC, NIC, and SIL values for position information. Transmit Quality Level **shall** address the following ASA Transmit subsystem characteristics:

- Minimum ASA equipment integrity
- Minimum ASA equipment availability
- Minimum ASA continuity of service
- Maximum data latency requirement for specified information elements
- Minimum report time accuracy
- Minimum NAC_p for position information
- Minimum NIC for position information
- Minimum SIL for position information
- Minimum BAQ for barometric altitude information
- Minimim SIL_{baro} for barometric altitude information
- Minimum transmitted information requirements (these are identified in §3.1.3)

The ASA Transmit subsystem transmit quality levels **shall** be determined as defined in Table 3.1-1.

<u>Table 3.1-1</u>: ASA Transmit Subsystem Transmit Quality Levels

<table>
<tr><th rowspan="2">Characteristic</th><th rowspan="2">Section Reference</th><th colspan="5">Transmit Quality Level</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><td>Minimum ASA Equipment Integrity</td><td>§3.1.1.1.1</td><td colspan="2">$>10^{-3}$ per hour</td><td>$\leq 10^{-3}$ per hour</td><td>$\leq 10^{-5}$ per hour</td><td>$\leq 10^{-7}$ per hour</td></tr>
<tr><td>Minimum ASA Equipment Availability</td><td>§3.1.1.1.2</td><td colspan="2">>0.95</td><td colspan="3">>0.9995</td></tr>
<tr><td>Minimum ASA Service Continuity</td><td>§3.1.1.1.3</td><td colspan="3">$<10^{-3}$ per hour</td><td>$\geq 10^{-5}$ per hour</td><td>$\geq 10^{-7}$ per hour</td></tr>
<tr><td>Maximum ASA Data Latency B1 → D1</td><td>§3.1.1.1.4</td><td colspan="3"><1.1 s 95%</td><td colspan="2"><0.3 s 95%</td></tr>
<tr><td>Maximum Nav Data Latency A1 → B1 A2 → B2</td><td>§3.1.1.1.5</td><td>≥2 s 95% Note 2</td><td><2 s 95%</td><td colspan="3"><1 s 95%</td></tr>
<tr><td>Minimum Report Time Accuracy</td><td>§3.1.1.1.6</td><td><1.0 s 95%</td><td colspan="4"><0.1 s 95%</td></tr>
<tr><td>Minimum NAC_p</td><td>§3.1.1.1.7</td><td>≤6</td><td>≥7</td><td>≥8</td><td colspan="2">≥9</td></tr>
<tr><td>Minimum NIC</td><td>§3.1.1.1.8</td><td>≤6</td><td>≥7</td><td>≥8</td><td colspan="2">>9</td></tr>
<tr><td>Minimum SIL</td><td>§3.1.1.1.9</td><td colspan="2">≥1 ($\geq 10^{-3}$ per hour)</td><td colspan="2">≥2 ($\geq 10^{-5}$ per hour)</td><td>3 ($\geq 10^{-7}$ per hour)</td></tr>
<tr><td>Minimum BAQ</td><td>§3.1.1.1.10</td><td>≤1</td><td>≥1</td><td>≥2</td><td>≥2</td><td>≥2</td></tr>
<tr><td>Minimum SIL_{baro}</td><td>§3.1.1.1.11</td><td>≤1</td><td>≥1</td><td>≥2</td><td>≥2</td><td>≥2</td></tr>
</table>

Notes to Table 3.1-1:

1. *Future versions of this MASPS may identify additional transmit quality characteristics.*

2. *When the latency of the navigation data exceeds 2 seconds, the age of the data needs to be transmitted to users so that they can account for latency when needed in the using application.*

The ASA Transmit subsystem **shall** assess that all of the requirements associated with a specific transmit quality level are met before transmitting that transmit quality level. When specified requirements are no longer met, the change in transmit quality level **shall** be transmitted within **1** seconds. The elements associated with Transmit Quality Level are defined by the following.

3.1.1.1.1 Minimum ASA Equipment Integrity

The minimum ASA equipment integrity **shall** be supported for a specific Transmit Quality Level. The ASA equipment integrity is the probability (per operating hour) of an undetected failure of the ASA transmit function that results in potentially erroneous information being transmitted. The probability includes the failures of the ASA Transmit subsystem equipment (STP and ADS-B transmit functions) but does not include the external surveillance information source sensors and systems.

Note: *The navigation position source equipment integrity is included in the SIL value that is transmitted.*

3.1.1.1.2 Minimum ASA Equipment Availability

The minimum ASA equipment operational availability **shall** be supported for a specific Transmit Quality Level. The probability includes the availability of the ASA Transmit subsystem equipment (STP and ADS-B transmit functions) but does not include the external surveillance information source sensors and systems.

3.1.1.1.3 Minimum ASA Service Continuity

The minimum ASA continuity of service probability (per operating hour) **shall** be supported for a specific Transmit Quality Level. The service continuity is the probability that the ASA Transmit function will not continue to provide surveillance information. The probability shall include: (1) ASA Transmit subsystem equipment and the surveillance information source equipment failure rates and (2) position source signal-in-space affects that can result in loss of valid position information. The continuity probability shall be based on continuing to provide surveillance data meeting the minimum NAC_p, NIC, and SIL values associated with the reported Transmit Quality level.

Note: *Continuity is specified at the ADS-B transmit antenna and does not include any signal-in-space affects or the reliability of the participant's receive side equipment.*

3.1.1.1.4 Maximum ASA Data Latency

The maximum latency of the transmitted dynamic aircraft state information that is attributable to the ASA Transmitting Subsystem that **shall** be supported for a specified Transmit Quality Level.

Note: *The latency is specified at the ADS-B transmit antenna and does not include ADS-B signal-n-space delays or any participant's receive latency contributions that are observed by applications. This latency value also does not include any data latencies inherent in the data presented to the ASA Transmit Subsystem by ASA information data sources.*

3.1.1.1.5 Maximum Navigation Data Latency

The maximum latency of the transmitted dynamic aircraft state information that **shall** be supported for a specified Transmit Quality Level.

Note: *This latency is specified at the the input to the ASA Transmit Subsystem and does not include any additional delays attributable to the ASA Transmit Subsystem or ASA Receiving Subsystem that may be seem by a using application.*

3.1.1.1.6 Minimum Report Time Accuracy

The maximum report time accuracy of the transmitted dynamic aircraft state information that **shall** be supported for a specified Transmit Quality Level. Each report of state information includes time of applicability information. Report time error is defined as the reported time of applicability minus the true time of applicability.

3.1.1.1.7 Minimum NAC_p

The minimum NAC_p value for the navigation data source that **shall** be supported for a specific Transmit Quality Level.

Note: *When an alternate navigation data source is selected, e.g. RNAV or INS, due to a failure of the primary source, the associated NAC_p for this source may require the reporting of a lower Transmit Quality Level.*

3.1.1.1.8 Minimum NIC

The minimum NIC value for the navigation data source that **shall** be supported for a specific Transmit Quality Level.

Note: *When an alternate navigation data source is selected, e.g. RNAV or INS, due to a failure of the primary source, the associated NIC for this source may require the reporting of a lower Transmit Quality Level.*

3.1.1.1.9 Minimum SIL

The minimum SIL value for the navigation data source that **shall** be supported for a specific Transmit Quality Level.

Note: *When an alternate navigation data source is selected, e.g. RNAV or INS, due to a failure of the primary source, the associated SIL for this source may require the reporting of a lower Transmit Quality Level.*

3.1.1.1.10 Minimum BAQ

The minimum BAQ value for the barometric altitude data source that **shall** be supported for a specific Transmit Quality Level.

3.1.1.1.11 Minimum SIL_{baro}

The minimum SIL_{baro} value for the barometric altitude data source that **shall** be supported for a specific Transmit Quality Level.

3.1.1.1.12 Minimum Transmit Information

The minimum ADS-B information that **shall** be transmitted for a specific Transmit Quality Level is identified in Section 3.1.3.

3.1.1.2 Application Capability Level

The "Application Capability Level" broadcast by the ASA Transmit subsystem indicates the surveillance applications that the on-board ASA system is capable of supporting. These are applications that are installed and certified for operational usage, however, the reported Application Capability Level does not necessarily indicate which application is currently selected and in use by the flight crew. The surveillance applications are grouped into sets of applications that support equipage levels and operational needs of the intended users. ADS-B equipment **shall** broadcast one of the Application Capability Levels that are defined in Section 2.4.1.

3.1.1.3 Navigation Data Processing

The navigation equipment available to support airborne surveillance systems will not be uniform among all ASA installations, therefore, there is a need to convert the data from navigation sources into the standard ADS-B data formats. Some of the required information elements will need to be determined based on the certified performance of the navigation sensor since appropriate data parameters are not output from the equipment. When multiple navigation sources are available to the ASA equipment, the use of the best available source will need to be assessed and selected. The following identifies the areas that require specific processing to provide the required surveillance data to the ADS-B Transmitting subsystem.

- Determination of navigation data quality
- Determination of accuracy (NAC_p, NAC_v)
- Determination of integrity radius of containment (NIC)
- Determination of navigation source integrity (SIL)
- Compensation for data latency
- Determination of common position reference point
- Management of multiple navigation data sources

3.1.1.3.1 Determination of Navigation Data Quality

The navigation data sources available to support ASA will not be uniform across all A/V, therefore, the appropriate values that define the quality of the navigation data that is transmitted will need to be determined. Some sources may output data parameters that meet the required ADS-B data definitions, however, other sources may require the available data outputs to be converted, interpreted, or formatted. In some cases, data will not be output from a source navigation sensor or system, therefore the values reported may need to be based on equipment certification values. The following sections define the criteria for determining the navigation data quality. Also see Appendix ?? for additional guidance on determining navigation quality from aircraft navigation systems.

3.1.1.3.1.1 Determination of NAC_p Values

The Navigation Accuracy Category for Position (NAC_p) to be associated with the transmitted geometric position information **shall** be obtained from the source providing the position information, when available. The STP function **shall** assign the appropriate NAC_p value based on the accuracy reported by the selected position source system (e.g. HFOM, VFOM, EPU, or VEPU) or as determined by validated methods when accuracy values are not reported. The reported values of NAC_p **shall** be those identified in §3.1.3.9. When accuracy values cannot be determined for a geometric position source, the geometric position accuracy **shall** be reported as unknown ($NAC_p = 0$).

Note: *For high NAC_p values, when the reported position is not corrected to that of the A/V position reference point and the antenna of the navigation sensor is not located in very close proximity to the A/V position reference point, the resulting position error may require the downgrade of the reported NAC_p value.*

3.1.1.3.1.2 Determination of NAC_v Values

The Navigation Accuracy Category for Velocity (NAC_v) to be associated with the transmitted geometric velocity information **shall** be obtained from the source providing the velocity information, when available. The STP function **shall** assign the appropriate NAC_v value based on the velocity accuracy reported by the selected velocity source system or as determined by validated methods when accuracy values are not reported. The reported values of NAC_v **shall** be those identified in §3.1.3.10. When accuracy values for velocity cannot be determined for a geometric velocity data source, the geometric velocity accuracy **shall** be reported as unknown ($NAC_v = 0$).

3.1.1.3.1.3 Determination of NIC Values

The Navigation Integrity Category (NIC) to be associated with the transmitted geometric position information **shall** be obtained from the source providing the position information. The reported values of NIC **shall** be those identified in §3.1.3.8. When position containment integrity values are not available from a geometric position source, the geometric position integrity **shall** be reported as unknown (NIC = 0). The maximum delay to report a change in position integrity (NIC) shall be 6 seconds.

3.1.1.3.1.4 Determination of SIL Values

The Surveillance Integrity Level (SIL) defines the probability for the horizontal integrity containment radius or vertical containment limit used in the NIC parameter being exceeded, without detection, including the effects of the airborne navigation equipment condition, which airborne navigation equipment is in use, and which external signals are used by the navigation source. The reported values of SIL **shall** be those identified in §3.1.3.11

SIL **shall** be defined as:

> "Probability of NIC exceedance without detection + Probability of navigation equipment failures affecting navigation data outputs without detection"

When an alternate navigation data source is selected for ASA, the reported SIL **shall** become the value for the new source that is selected.

Note: SIL is assumed to be a static value that is determined for each candidate on-board navigation data source equipment that is certified for surveillance purposes.

3.1.1.3.1.5 Determination of Measurement Time of Applicability

It **shall** be possible for a receiving participant to assess the time of applicability of the aircraft state data transmitted. When the transmitted aircraft state data meets the data latency requirements specified in Section 3.1.1.1.5, the time of applicability may be the time of transmission when receiving systems provide time stamping for determination of time of applicability. Otherwise, a common time of applicability for the transmitted aircraft state data **shall** be determined and transmitted. When the latency of the aircraft state data exceeds 2 seconds, the age of the state data **shall** be determined and transmitted in a message to other receiving participants. Data age is defined as difference between the time of transmission of the state data and the actual state data measurement time.

3.1.1.3.2 Determination of Common Position Reference Point

The common surveillance *position reference point* of an A/V **shall** be defined as the center of a rectangle (the "defining rectangle for position reference point") that has the following properties:

a. The defining rectangle for position reference point **shall** have length and width code as defined in Table 3.1-5 below.

b. The defining rectangle for position reference point **shall** be aligned parallel to the A/V's heading.

c. The ADS-B position reference point (the center of the defining rectangle for position reference point) **shall** lie along the axis of symmetry of the A/V. (For an asymmetrical A/V, the center of the rectangle should lie midway between the maximum port and starboard extremities of the A/V.)

d. The forward extremity of the A/V **shall** just touch the forward end of the defining rectangle for position reference point.

Table 3.1-5: Dimensions of Defining Rectangle for Position Reference Point

A/V - L/W Code	Defining Rectangle Dimensions	
	Length	Width
0	<15 m	<11.5 m
1		<23 m
2	<25 m	<28.5 m
3		<34 m
4	<35 m	<33 m
5		<38 m
6	<45 m	<39.5 m
7		<45 m
8	<55 m	<45 m
9		<52 m
10	<65 m	<59.5 m
11		<67 m
12	<75 m	<72.5 m
13		<80 m
14	≥75 m	<80 m
15		≥80 m

Note: *The lengths and widths given are least upper bounds for the possible lengths and widths of an aircraft. An exception, however, is made for the largest length and width codes, since there is no upper bound for the size of an aircraft that broadcasts those largest length and width codes.*

Figure 3.1-2 illustrates the location of the ADS-B reference point, for an example aircraft of length 31 m and width 29m. Such an aircraft will have length code 4 (L < 35 m and W < 33m). The ADS-B position reference point is then the center of a rectangle that is 35 m long and 33 m wide and positioned as given in the requirements just stated.

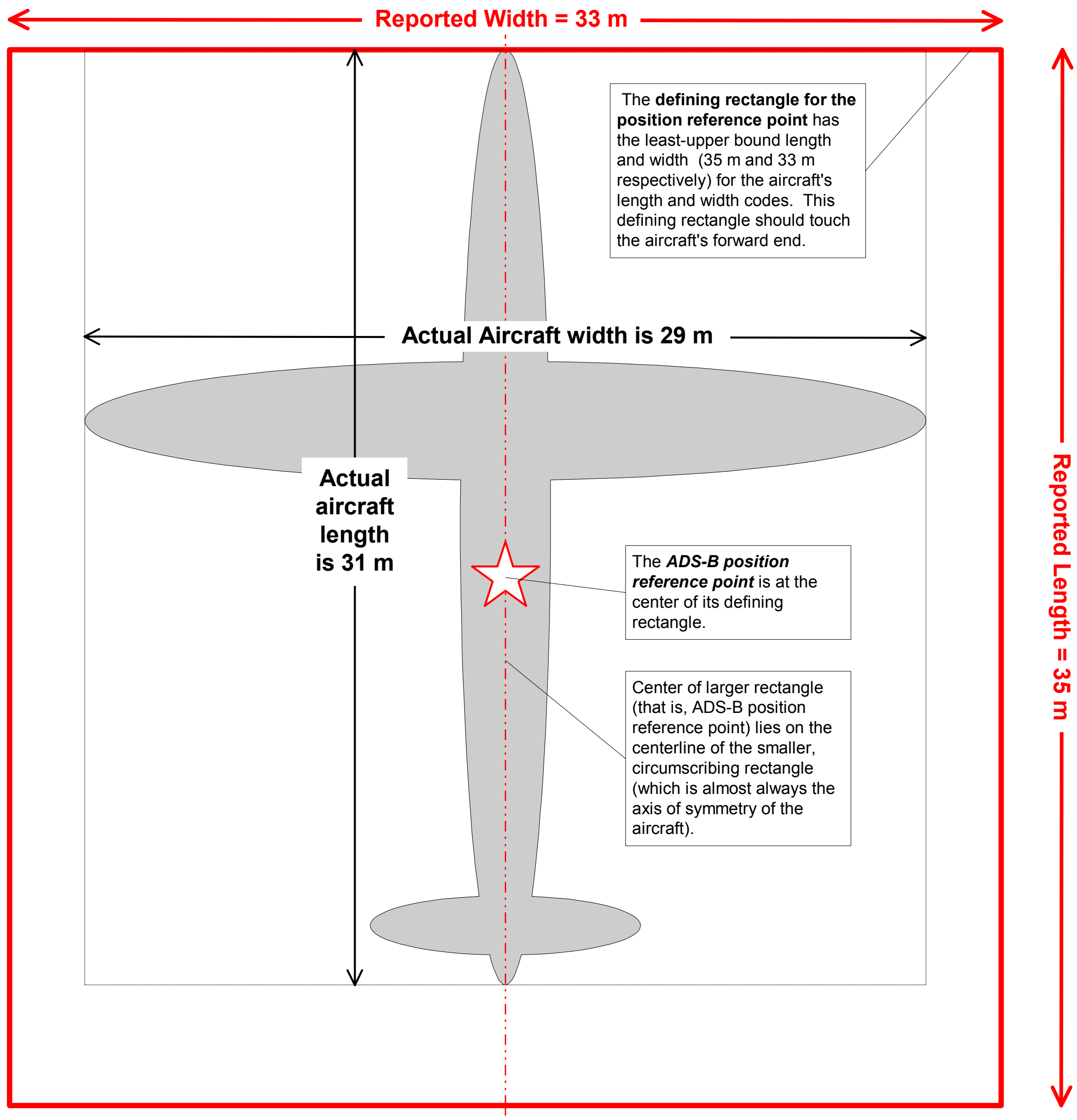

Figure 3.1-2: Position Reference Point Definition.

3.1.1.3.3 Management of Navigation Data Sources

It is assumed that the majority of ASA installations will be equipped with GNSS as their primary geometric position and velocity data source. Less capable navigation systems, such as RNAV and INS, will be used primarily as back-up sources. As such, the requirements for the selection and management of multiple navigations sources will need to be specified. The following requirements apply.

1. The navigation data source **shall** be capable of providing geometric position and velocity data suitable for surveillance based applications.
2. The navigation data **shall** include the following:
   - Own vehicle horizontal position in latitude and longitude
   - Own vehicle velocity (true north & east). (Ground speed/ground track may be used if velocity $_{north/east}$ is not available. Ground track requires a discrete to indicate true/mag reference.)
   - Own vehicle geometric height above ellipsoid surface, if available.
   - Position and velocity validity flags
3. The navigation data **shall** be accompanied with accuracy and integrity metrics for determination of Navigation Integrity Category (NIC) and Navigation Accuracy Category (NAC_P for position and NAC_V for velocity) of the data.
4. There **shall** be a means to determine the SIL value for the navigation data source.
5. When a navigation data source fails, the source selection **shall** follow a priority order for available sources. When there are multiple sources of the same source type, the same type source **shall** be selected prior to selection of a lower navigation data source.
   - Primary Source shall be a GNSS sensor certified for navigational usage.
   - Secondary Source may be a RNAV or INS system capable of providing at least geometric horizontal position. The selection of RNAV or INS sources, when both are available, shall be based on the source that supports the highest Transmit Quality level. Combining of data from multiple sources may be used to provide the highest quality navigation data.

A navigation data source **shall** be declared failed when the position validity indicates Failed state. The switch over from a failed data source to another source **shall** occur within **1** seconds after the current source is declared failed.

3.1.1.4 Air/Ground Assessment Processing

A transmitting participant's air/ground state **shall** have the following possible values:

- "Known to be airborne,"
- "Known to be on the surface"
- "Uncertain whether airborne or on the surface"

A transmitting ADS-B participant **shall** apply the following tests to determine its air/ground state:

1. If a transmitting ADS-B participant is *not* equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is one of the following, then it **shall** set its air/ground state to "known to be airborne":
   - Light Aircraft
   - Glider or Sailplane
   - Lighter Than Air

- Unmanned Aerial Vehicle
- Ultralight, Hang Glider, or Paraglider
- Parachutist or Skydiver
- Point Obstacle
- Cluster Obstacle
- Line Obstacle

2. If a transmitting ADS-B participant is *not* equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is one of the following, then that participant **shall** set its air/ground state to "known to be on the surface" :
   - Surface Vehicle – Emergency
   - Surface Vehicle – Service
3. If a transmitting ADS-B participant is *not* equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and that participant's emitter category is "rotorcraft," then that participant **shall** set its air/ground state to "uncertain whether airborne or on the surface."
4. If a transmitting ADS-B participant is *not* equipped with a means, such as a weight-on-wheels switch, to determine whether it is airborne or on the surface, and its ADS-B emitter category is not one of those listed under tests 1, 2, and 3 above, then that participant's ground speed (GS), airspeed (AS) and radio height (RH) **shall** be examined, provided that some or all of those three parameters are available to the transmitting ADS-B subsystem. If GS < 100 knots, or AS < 100 knots, or RH < 100 feet, then the transmitting ADS-B participant **shall** set its Air/Ground state to "known to be on the surface."
5. If a transmitting ADS-B participant *is* equipped with a means, such as a weight-on-wheels switch, to determine automatically whether it is airborne or on the surface, and that automatic means indicates that the participant is airborne, then that participant **shall** set its air/ground state to "known to be airborne."

6. If a transmitting ADS-B participant _is_ equipped with a means, such as a weight-on-wheels switch, to determine automatically whether it is airborne or on the surface, and that automatic means indicates that the participant is on the surface, then the following additional tests **shall** be performed to validate the "on-the-surface" condition:

   a. If the participant's ADS-B emitter category is any of the following:
      "Small Aircraft" or
      "Medium Aircraft" or
      "High-Wake-Vortex Large Aircraft" or
      "Heavy Aircraft" or
      "Highly Maneuverable Aircraft" or
      "Space or Trans-atmospheric Vehicle"

      and one or more of the following parameters is available to the transmitting ADS-B system:
      Ground Speed (GS) or
      Airspeed (AS) or
      Radio height from radio altimeter (RH)

      and any of the following conditions is true:
      GS > 100 knots or
      AS > 100 knots or
      RH > 100 ft,

      then the participant **shall** set its Air/Ground state to "known to be airborne."

   b. Otherwise, the participant **shall** set its Air/Ground state to "known to be on the surface."

3.1.1.5 (Reserved) Intent Data Processing

In future versions of this MASPS, the requirements for intent data processing will be defined.

3.1.2 ADS-B Transmitting Subsystem Requirements

The ADS-B Transmitting subsystem, represented by interfaces C-D in Figure 3-1, works in concert with other aircraft or ground systems ADS-B Receiving subsystems. The ADS-B MASPS (DO-242) and its revisions **shall** specify transmit requirements such that they are broadcast link media independent, to the extent possible, and to allow flexibility in the manner that messages are transmitted and received to create ADS-B surveillance reports that are provided to ASA Applications. The transmitting ADS-B subsystem on the transmitting aircraft and the ADS-B Receiving subsystem on a receiving aircraft in combination need to meet requirements for data reception reliability, reception range, and update rate requirements in the expected operational environments, as specified in Section 3.2.

ADS-B Transmitting subsystem functional capabilities include: 1) accept source data inputs, 2) assemble and encode the required ADS-B messages, 3) broadcast transmit the messages, 4) monitor for proper operation, and 5) provide notification of transmit system status.

3.1.3 ASA Transmit Subsystem Interface Requirements

The ASA Transmit subsystem requires interfaces to many existing and envisioned on-board avionics system and sensors for the surveillance information to be broadcast. The range of aircraft types and models that may be equipped with an ASA Transmit subsystem result in a wide variation in avionics systems and sensors providing surveillance data. Not all aircraft will be able to provide all surveillance data elements. The following is a non-inclusive list of candidate surveillance data sources.

- GNSS sensors
- RNAV systems
- Inertial navigation systems
- Air data systems
- Heading reference systems
- Flight management systems
- Auto-flight systems
- Flight ID sources
- TCAS systems
- Aircraft state equipment, e.g. Weight-on-wheels

Note: *This MASPS addresses the surveillance information to be extracted from source avionics systems. The integration of ASA Transmit subsystem equipment into a candidate aircraft will establish the necessary physical interfaces, data conversions, and data formatting required. This is to be addressed by lower level MOPS documents.*

The following tables identify the surveillance data elements to be broadcast. The source equipment, in general terms, will be identified. In some cases, the fundamental source may be the from the Surveillance Transmit Processing subsystem for uniquely computed information elements. These items are identified in the paragraph (§3.1.2) above. The surveillance information required to be transmitted by ASA Transmit subsystem that is reporting a specific Service Level are indicated by "●". Other information elements that are "desired" are indicated by "d".

Table 3.1-6: ASA Transmit Subsystem Information Elements

Information Category	Information Element	Source	Transmit Quality Level 0	1	2	3	4	Notes
A/V Identification	Call Sign	A/V System	d	d	•	•	•	
	A/V Address & Address Qualifier	A/V System	•	•	•	•	•	
	A/V Category	STP	•	•	•	•	•	
	A/V Length and Width Code	STP	•	•	•	•	•	1
Navigation	Horizontal Position	GNSS, RNAV, INS	•	•	•	•	•	3
	Horizontal Position Valid	GNSS, RNAV, INS	•	•	•	•	•	
	Position Reference Point	STP						4
	NAC_p	STP	•	•	•	•	•	
	Horizontal Velocity	GNSS, RNAV, INS	•	•	•	•	•	3
	Horizontal Velocity Valid	GNSS, RNAV, INS	•	•	•	•	•	
	NAC_v	STP	•	•	•	•	•	
	Geometric Altitude	GNSS, RNAV, INS	•	•	•	•	•	3
	Geometric Altitude Valid	GNSS, RNAV, INS	•	•	•	•	•	
	Geometric Altitude Rate	GNSS, RNAV, INS	•	•	•	•	•	2, 3
	Geometric Altitude Rate Valid	GNSS, RNAV, INS	•	•	•	•	•	2
	NIC	STP	•	•	•	•	•	
	SIL	STP	•	•	•	•	•	
Air Data	Barometric Altitude	Air Data	•	•	•	•	•	3
	Barometric Altitude Valid	Air Data	•	•	•	•	•	
	BAQ	STP	•	•	•	•	•	
	SIL_{baro}	STP	•	•	•	•	•	
	Barometric Vertical Rate	Air Data	•	•	•	•	•	2
	Barometric Vertical Rate Valid	Air Data	•	•	•	•	•	2
Heading	Heading (True or Magnetic)	Heading	d	d	•	•	•	5
	Heading Valid	Heading	d	d	•	•	•	5
Aircraft State	Air/Ground State	STP	d	d	•	•	•	
ASA Equipment	Transmit Quality Level	STP	•	•	•	•	•	
	Ownship Application Capability Level	STP	•	•	•	•	•	
	ASA Capability Identification	STP	•	•	•	•	•	
Operating State	Operational Mode Parameters	STP	•	•	•	•	•	

• = Required; d = desired

<u>Notes for Table 3.1-6</u>:

1. *To be transmitted while A/V is know to be on the surface when A/V is of Length and Width Code of 2 or greater.*

2. *At least one of the two types of vertical rate (barometric or geometric) is to be broadcast. The type of vertical rate provided is to be indicated.*

3. *Each of these information elements is to be translated to a common time of applicability (TOA) prior to broadcast. The TOA value does not need to be transmitted if it can be determined by a receiving participant with a latency no greater than **TBD**.*

4. *The Position Reference Point is not a broadcast information element. It is used to translate, when required, the horizontal position from a navigation source to a standard A/V reference location prior to broadcast.*

5. *Heading is required while operating on the airport surface for aircraft with A/V Length and Width codes of 2 or greater.*

The ASA Transmit subsystem **shall** be capable of transmitting messages containing the surveillance information specified in the following subsections. The parameter range and resolution will be specified where appropriate.

3.1.3.1 A/V Identification

The basic identification information to be conveyed **shall** include the following elements:

- Call Sign
- A/V Address and Address Qualifier
- A/V Category
- A/V Length and Width Codes

3.1.3.1.1 Call Sign

The ASA Transmit subsystem **shall** convey an aircraft call sign of up to 8 alphanumeric characters in length.

3.1.3.1.2 A/V Address and Address Qualifier

The ASA Transmit subsystem **shall** transmit a locally unique address that enables a user to:

a. correlate all messages transmitted regarding the A/V, and
b. differentiate the A/V from other A/Vs in the operational domain.

3.1.3.1.2.1 A/V Address

The ASA Transmit subsystem **shall** transmit either the ICAO 24-bit addressed assigned to the A/V or another kind of address that is unique within the operational domain, as determined by the A/V Address Qualifier.

3.1.3.1.2.2 A/V Address Qualifier

The A/V Address Qualifier **shall** be used to describe whether or not the A/V Address contains the 24-bit ICAO address for the A/V or another kind of address.

Note: *Not all A/V are assigned ICAO addresses.*

3.1.3.1.3 A/V category

The ASA Transmit subsystem **shall** transmit an A/V Category code. Category describes the type of A/V of the transmitter to other users. The A/V Category transmitted **shall** be one of the following A/V types:

- Light (ICAO) - 7,000 kg (15,500 lbs) or less
- Small aircraft – 7,000 kg to 34,000 kg (15,500 lbs to 75,000 lbs)
- Large aircraft – 34,000 kg to 136,000 kg (75,000 lbs to 300,00 lbs)
- High vortex large (aircraft such as B-757)
- Heavy aircraft (ICAO) - 136,000 kg (300,000 lbs) or more
- Highly maneuverable (> 5g acceleration capability) and high speed (> 400 knots cruise)
- Rotorcraft
- Glider/Sailplane
- Lighter-than-air
- Unmanned Aerial vehicle
- Space/Trans-atmospheric vehicle
- Ultralight / Hang glider / Paraglider
- Parachutist/Skydiver
- Surface Vehicle - emergency vehicle
- Surface Vehicle - service vehicle
- Point obstacle (includes tethered balloons)
- Cluster obstacle
- Line obstacle

Notes:

1. *ICAO Medium aircraft – 7,000 to 136,000 kg (15,500 to 300,000 lbs) can be represented as either small or large aircraft as defined above.*
2. *Obstacles can be either fixed or movable. Movable obstacles would require a position source.*
3. *Weights given for determining participant categories are maximum gross weights, not operating weights.*

3.1.3.1.4 A/V Length and Width Codes

The ASA Transmit subsystem **shall** transmit codes that identify the A/V length and width, per Table 3.1-5 in section 3.1.1.3.2, when the A/V code is 2 or more and the A/V is known to be on the surface. The A/V length and width codes describe the amount of space that an aircraft or ground vehicle occupies.

3.1.3.2 Horizontal Position

The horizontal position of the A/V **shall** be transmitted in a form that can be translated, without loss in accuracy and integrity for the reported NAC_p and NIC codes, into latitude and longitude referenced to WGS-84 ellipsoid. Horizontal position communicated **shall** support the full range of possible latitudes (-90° to +90°) and longitudes (-180° to +180°). The validity of the horizontal position information **shall** be transmitted.

Horizontal position **shall** be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_P code.

Note: *It is likely that future surface movement and runway inclusion applications will require high NAC_p values. To obtain those high values, it may be necessary to correct the reported position to that of the A/V position reference point if the antenna of the navigation sensor is not located in very close proximity to the A/V position reference point.*

3.1.3.3 Position Reference Point

The nominal location of a transmitting A/V – the surveillance position that is reported to user applications in state information about that A/V – is the location of the A/V's Position Reference Point, as defined in section 3.1.1.3.2. The transmitted ADS-B position **shall** be corrected to this reference position when necessary to achieve the reported accuracy in NAC_p value. When the transmitted position is not corrected to the Position Reference Point, the resulting error in position **shall** be included in the NAC_p value that is reported. The Position Reference Point is not required to be transmitted to other participants.

3.1.3.4 Horizontal Velocity

The horizontal velocity of the A/V **shall** be transmitted in north-south and east-west velocity components relative to the WGS-84 coordinate system. The validity of the horizontal velocity information **shall** be transmitted. Horizontal velocity **shall** be provided with a range to accommodate speed of up to 4000 knots for airborne participants and up to 250 knots for surface participants.

Horizontal velocity **shall** be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_V code.

3.1.3.5 Altitude

Both barometric pressure altitude and geometric altitude (height above the WG84 ellipsoid) **shall** be transmitted, if available to the ASA Transmit subsystem. When an A/V is operating on the airport surface and is indicating that it is on the surface, the transmission of altitude is not required. Altitude **shall** be provided with a range from –1,000 ft up to +100,000 ft. For fixed or movable obstacles, the altitude of the highest point should be reported.

3.1.3.5.1 Barometric Altitude

The barometric altitude of the A/V **shall** be transmitted referenced to standard temperature and pressure. The validity of the barometric altitude information **shall** be transmitted.

If a pressure altitude source with 25 foot or better resolution is available to the ADS-B transmitting subsystem, then pressure altitude from that source **shall** be communicated and reported with 25 foot or finer resolution. Otherwise, if a pressure altitude source with 100 foot or better resolution is available, pressure altitude from that source **shall** be communicated and reported with 100 foot or finer resolution.

3.1.3.5.2 Geometric Altitude

The geometric altitude of the A/V **shall** be transmitted as the shortest distance from the current aircraft position to the surface of the WGS-84 ellipsoid. Geometric altitude **shall** be indicated as positive for positions above the WGS-84 ellipsoid surface, and negative for positions below that surface. The validity of the geometric altitude information **shall** be transmitted.

Geometric altitude **shall** be communicated and reported with a resolution sufficiently fine that it does not compromise the vertical accuracy reported in the NAC_P code.

3.1.3.6 Vertical Rate

A/Vs that are a not fixed or movable obstacle and that are not known to be on the airport surface **shall** provide vertical rate. Vertical Rate **shall** be designated as climbing or descending and **shall** be reported up to 32,000 feet per minute (fpm). The validity of the vertical rate information **shall** be transmitted.

Barometric altitude rate is defined as the current rate of change of barometric altitude. Likewise, geometric altitude rate is the rate of change of geometric altitude. At least one of the two types of vertical rate (barometric and geometric) **shall** be transmitted. An indication of which type of altitude rate is being transmitted **shall** be provided.

Geometric vertical rate **shall** be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_V code.

3.1.3.7 Heading

Heading **shall** indicate the orientation of an A/V, that is, the direction in which the nose of the aircraft is pointing. Heading **shall** be indicated as an angle measured clockwise from true north or magnetic north. An indication **shall** be provided as to whether the heading is measured from true north or magnetic north. The heading transmitted **shall** support the full range of possible headings (full circle from 0° to nearly 360°). The heading of surface participants **shall** be communicated with a resolution of 6° of arc or finer. The accuracy (95%) of the heading source shall be ±10° or better. The validity of the heading information **shall** be transmitted.

Note: *Heading is required for surface applications only.*

3.1.3.8 Navigation Integrity Category (NIC)

The Navigation Integrity Category (NIC) is transmitted so that surveillance applications may determine whether the transmitted position has an acceptable level of integrity for the intended use by a receiving system. The NIC parameter specifies an integrity containment radius, R_C for the transmitted position.

Table 3.1-7 defines the navigation integrity categories that transmitting ADS-B participants **shall** use to describe the integrity containment radius, R_C, associated with the horizontal position information in ADS-B messages.

Table 3.1-7: Navigation Integrity Categories (NIC).

NIC (Note 1)	Horizontal and Vertical Containment Bounds	Comment	Notes
0	$R_C \geq$ 37.04 km (20 NM)	Unknown Position Integrity	
1	$R_C <$ 37.04 km (20 NM)	RNP-10 containment radius	4
2	$R_C <$ 14.816 km (8 NM)	RNP-4 containment radius	4
3	$R_C <$ 7.408 km (4 NM)	RNP-2 containment radius	4
4	$R_C <$ 3.704 km (2 NM)	RNP-1 containment radius	4
5	$R_C <$ 1852 m (1 NM)	RNP-0.5 containment radius	4
6	$R_C <$ 1111.2 m (0.6 NM)	RNP-0.3 containment radius	4
7	$R_C <$ 370.4 m (0.2 NM)	RNP-0.1 containment radius	4
8	$R_C <$ 185.2 m (0.1 NM)	RNP-0.05 containment radius	4
9	$R_C <$ 75 m and VPL < [112 m]	e.g., WAAS HPL, VPL	2, 3
10	$R_C <$ 25 m and VPL < [37.5 m]	e.g., WAAS HPL, VPL	2, 3
11	$R_C <$ 7.5 m and VPL < [11 m]	e.g., LAAS HPL, VPL	2, 3

Notes for Table 3.1-7:

1. *NIC is reported by an aircraft because there will not be a uniform level of navigation equipage among all users. Although GNSS is intended to be the primary source of navigation data used to report ADS-B horizontal position, it is anticipated that during initial uses of ADS-B or during temporary GNSS outages an alternate source of navigation data may be used by the transmitting A/V for ADS-B position information. The integration of alternate navigation sources is a function that must be performed by the ASA Surveillance Transmit Processing, which then is responsible for determining the corresponding integrity containment radius.*
2. *HPL may be used to represent R_C for GNSS sensors.*
3. *If geometric altitude is not being reported then the VPL tests are not assessed.*
4. *RNP containment integrity refers to total system error containment including sources other than sensor error, whereas horizontal containment for NIC only refers to sensor position error containment.*

3.1.3.9 Navigation Accuracy Category for Position (NAC_p)

The Navigation Accuracy Category for Position (NAC_P) is reported so that surveillance applications may determine whether the reported position has an acceptable level of accuracy for the intended use.

Table 3.1-8 defines the navigation accuracy categories that **shall** be used to describe the accuracy of positional information in ADS-B messages from transmitting ADS-B participants.

Table 3.1-8: Navigation Accuracy Categories for Position (NAC_P).

NAC_P	95% Horizontal and Vertical Accuracy Bounds (EPU and VEPU)	Comment	Notes
0	EPU ≥ 18.52 km (10 NM)	Unknown accuracy	3
1	EPU < 18.52 km (10 NM)	RNP-10 accuracy	1,3
2	EPU < 7.408 km (4 NM)	RNP-4 accuracy	1,3
3	EPU < 3.704 km (2 NM)	RNP-2 accuracy	1,3
4	EPU < 1852 m (1NM)	RNP-1 accuracy	1,3
5	EPU < 926 m (0.5 NM)	RNP-0.5 accuracy	1,3
6	EPU < 555.6 m (0.3 NM)	RNP-0.3 accuracy	1,3
7	EPU < 185.2 m (0.1 NM)	RNP-0.1 accuracy	1,3
8	EPU < 92.6 m (0.05 NM)	e.g., GPS (with SA)	1,3
9	EPU < 30 m and VEPU < 45 m	e.g., GPS (SA off)	2,3,4
10	EPU < 10 m and VEPU < 15 m	e.g., WAAS	2,3,4
11	EPU < 3 m and VEPU < 4 m	e.g., LAAS	2,3,4

Notes for Table 3.1-8:

1. *RNP accuracy includes error sources other than sensor error, whereas horizontal error for NAC_P only refers to horizontal position error uncertainty.*
2. *If geometric altitude is not being reported then the VEPU tests are not assessed.*
3. *The Estimated Position Uncertainty (EPU) used is a 95% accuracy bound on horizontal position. EPU is defined as the radius of a circle, centered on the reported position, such that the probability of the actual position being outside the circle is 0.05. When reported by a GPS or GNSS system, EPU is commonly called HFOM (Horizontal Figure of Merit).*
4. *Likewise, Vertical Estimated Position Uncertainty (VEPU) is a 95% accuracy limit on the vertical position. VEPU is defined as a vertical position limit, such that the probability of the actual vertical position differing from the reported vertical position by more than that limit is 0.05. When reported by a GPS or GNSS system, VEPU is commonly called VFOM (Vertical Figure of Merit).*

3.1.3.10 Navigation Accuracy Category for Velocity (NAC_v)

The velocity accuracy category of the least accurate velocity component being supplied by the reporting A/V's source of velocity data **shall** be as indicated in Table 3.1-9.

Table 3.1-9: Navigation Accuracy Categories for Velocity (NAC_V).

NAC_V	Horizontal Velocity Error (95%)	Vertical Geometric Velocity Error (95%)
0	Unknown or ≥ 10 m/s	Unknown or ≥ 50 feet (15.24 m) per second
1	< 10 m/s	< 50 feet (15.24 m) per second
2	< 3 m/s	< 15 feet (4.57 m) per second
3	< 1 m/s	< 5 feet (1.52 m) per second
4	< 0.3 m/s	< 1.5 feet (0.46 m) per second

Notes for Table 3.1-9:

1. *When an inertial navigation system is used as the source of velocity information, error in velocity with respect to the earth (or to the WGS-84 ellipsoid used to represent the earth) is reflected in the NAC_V value.*
2. *When any component of velocity is flagged as not available the value of NAC_V will apply to the other components that are supplied.*
3. *Navigation sources, such as GNSS and inertial navigation systems, provide a direct measure of velocity that can be significantly better than that which could be obtained by position differences.*
4. *NAC_V does not apply to barometric velocity accuracy.*

3.1.3.11 Surveillance Integrity Level (SIL)

The Surveillance Integrity Level (SIL) defines the probability of the integrity containment radius used in the NIC parameter being exceeded, without alerting, including the effects of the airborne equipment condition, which airborne equipment is in use, and which external signals are used by the navigation source. The Surveillance Integrity Limit encoding **shall** be as indicated in Table 3.1-10.

Table 3.1-10: Surveillance Integrity Level (SIL) Encoding.

SIL	SIL_E	Probability of Exceeding the R_C Integrity Containment Radius Without Detection	Comment
0	0	Unknown	"No Hazard Level" Navigation Source
0	1	$\leq 1 \times 10^{-2}$ per flight hour	
1	0	$\leq 1 \times 10^{-3}$ per flight hour	"Minor Hazard Level" Navigation Source
1	1	$\leq 1 \times 10^{-4}$ per flight hour	
2	0	$\leq 1 \times 10^{-5}$ per flight hour	"Major Hazard Level" Navigation Source
2	1	$\leq 1 \times 10^{-6}$ per flight hour	
3	0	$\leq 1 \times 10^{-7}$ per flight hour	"Severe Major Hazard Level" Navigation Source
3	1	Reserved or $\leq 1 \times 10^{-8}$ per flight hour	

Notes for Table 3.1-10:

1. *It is assumed that SIL is a static (unchanging) value that depends on the position sensor being used. Thus, for example, if an ADS-B participant reports a NIC code of 0 because four or fewer satellites are available for a GPS fix, there would be no need to change the SIL code until a different navigation source were selected for the positions being reported in the SV report.*
2. *SIL is only stated as a per hour probability as transmitting aircraft do not know the intended application of receiving participants.*
3. *SIL_E is used to determine intermediate Surveillance Integrity Level while retaining compatibility with prior systems implementing only the SIL levels.*

3.1.3.12 Barometric Altitude Quality (BAQ)

The Barometric Altitude Quality code, BAQ, **shall** indicate the accuracy quality of the barometric altitude transmitted and **shall** be encoded as defined in Table 3.1-11.

Table 3.1-11: Encoding for Barometric Altitude Quality (BAQ).

BAQ	Barometric Altitude Error	Notes
0	Unknown	
1	≤250 feet (95%)	1
2	Basic RVSM (ASE = 160 feet)	2
3	Full RVSM (ASE = 200 feet)	3

Notes to Table 3.1-11:

1. *Barometric altimetry source equipment qualified to TSO C-10b.*

2. *Barometric altimetry source equipment qualified and maintained for Basic RVSM flight envelope altimetry accuracy. ASE (aircraft group) = 200 feet 3σ*

3. *Barometric altimetry source equipment qualified and maintained for Full RVSM flight envelope altimetry accuracy. (Note that Full RVSM ASE is expected to meet or exceed the Basic RVSM ASE when within the reduced flight envelope of Basic RVSM.) ASE(aircraft group) = 245 feet 3σ*

4. *Altimetry System Error (ASE) is the difference between the pressure altitude displayed to the flightcrew when referenced to ISA standard ground pressure setting (29.92 in. Hg/1013.25 hPa) and free stream pressure altitude. ASE requirement for individual aircraft includes residual static source error plus worst-case avionics errors. (Note that the group aircraft RVSM ASE requirements that address group error statistics, e.g. aircraft-to-aircraft variations, therefore are not applicable for this requirement.)*

3.1.3.13 Barometric Altitude Integrity Level (SIL_{baro})

The Barometric Altitude Integrity Level code, $SIL_{baro,}$ **shall** indicate the undetected error rate of the barometric altitude data source equipment and **shall** be encoded as defined in Table 3.1-12.

Table 3.1-12: Encoding for Barometric Altitude Integrity Level (SIL_{baro}).

SIL_{baro}	Undetected Error Rate	Notes
0	Unknown or >1 x 10^{-3} per flight hour	
1	$\leq 1 \times 10^{-3}$ per flight hour	
2	$\leq 1 \times 10^{-5}$ per flight hour	1
3	$\leq 1 \times 10^{-7}$ per flight hour	2

Notes for Table 3.1-12:

1. *Barometric altitude source equipment integrity level when qualified for RVSM.*

2. *Barometric pressure altitude that has been crosschecked against another source of pressure altitude.*

3.1.3.14 Air/Ground State

The ADS-B transmitting subsystem **shall** use own aircraft's *air/ground state* to affect which surveillance elements are to be broadcast. The air/ground state **shall** be broadcast in ADS-B messages to other participants.

3.1.3.15 ASA Capability Identification

The ADS-B transmitting subsystem **shall** provide for the transmission of ASA capability identification codes. These codes communicate the following items:

a. TCAS/ACAS installed and operational

b. CDTI display capable

c. Reporting ADS-B Reference Position

d. ASA version number

Note: Future versions of this MASPS may identify additional ASA capability items, therefore provisions should be made to accommodate this future growth.

3.1.3.16 Operational Mode Parameters

The ADS-B transmitting subsystem **shall** provide for the transmission of operational mode parameters. These parameters include the following items:

a. TCAS/ACAS Resolution Advisory active

b. IDENT Switch active

c. Receiving ATC services

d. Emergency/Priority Status

Note: Future versions of this MASPS may identify additional Operational Mode Parameters, therefore provisions should be made to accommodate this future growth.

3.1.3.17 (Reserved) Intent Information

Future versions of this MASPS will provide requirements for intent information elements.

3.2 Data Link System Requirements

Various data links will be used for the transmission and reception of surveillance information supporting ASA systems. This includes both the systems used (e.g. ADS-B and TIS-B) and the media on which the data is transmitted (e.g. 1090 MHz Extended Squitter, UAT, or VDL-4). It is necessary to make sure that any system or medium used to convey ASA data does so at a level sufficient to support ASA applications and allow ASA systems to function as specified elsewhere in these MASPS. The requirements specified in this section are meant to set high level functional and performance standards for surveillance data links supporting ASA. These requirements are to be met from interfaces C1 & C2 through E as depicted in Figure 2-9. More detailed system standards can be found in the ADS-B MASPS (DO-242A) and TIS-B MASPS (DO-286). Specific system performance requirements can be found in the data link MOPS for 1090 MHz (DO-260A) and UAT (DO-182) as well as the VDL-4 SARPS (document reference??)

3.2.1 Data Link Media Functional Requirements

Operational Environment

The ASA Surveillance Data Link (i.e. ADS-B, TIS-B) RF medium **shall** be suitable for all-weather operation. Radio frequencies used for ASA Surveillance message transmission **shall** operate in an internationally allocated aeronautical radionavigation band(s). Data Link system performance will be specified relative to a defined interference environment for the medium.

Minimum Functionality

ASA is dependant on the appropriate surveillance data being available under expected operating conditions. The ASA Surveillance Data Link medium **shall** be able to support air-to-air and air-to-ground transfer of data for ADS-B systems and ground-to-air transfer of data for TIS-B systems.

It is important that messages from different data link systems such as ADS-B and TIS-B be distinguishable from each other. Messages **shall** be encoded such that the transmitting system of the message (i.e. ADS-B, TIS-B) can be identified. Further, every system **shall** convey the version of requirements for which it complies. The use of a version number will facilitate backwards compatibility and allow applications to appropriately interpret received data.

3.2.2 **Note: Version numbers can be coded to the version of lower level documents such as link MOPS to which the system was designed. This can then be translated to the ADS-B/TIS-B MASPS and ASA MASPS versions to which those minimum requirements were written. Data Link System Performance Requirements**

3.2.2.1 Data Exchange Requirements

Any data link system used to support ASA must be able to perform at levels and ranges as required by the supported ASA applications. Minimum performance requirements for each Application Capability Level are specified in Table 2-4 (§2.4.5). All data link systems supporting a particular Application Capability Level must meet those performance requirements.

The data transmitted by an ASA participant **shall** be of sufficient quality (as specified in Table 2-4) to *support* those applications for which the ASA participant can *perform* as indicated by its Application Capability Level. While these MASPS do not place minimum quality standards on transmitted data, they do require that ASA participants transmit data of the same quality that is needed for the applications that an ASA system is capable of running. Since TIS-B is only a provider of data for ASA applications, no minimum performance or quality requirements are specified for TIS-B transmitting subsystems. However, for an ASA receiving subsystem to use TIS-B data, that data must meet the minimum requirements specified in these subsections and in §2.4.5.

Different data elements transmitted and received by ASA participants have differing degrees of volatility, or rate of change. While state vector information such as position, heading, and velocity change almost continuously when an aircraft is in motion, other attributes such as identification fields, emitter categories, and current operational status change infrequently, if at all. Given these attributes for different data elements, and the need by all data link systems and frequencies to conserve bandwidth to meet all informational and performance requirements, data elements of common volatility and purpose are likely to be grouped together in any system's defined message set. This allows systems and particular links to broadcast state vector data at a much higher rate than identification information and other more static data elements. On the receive side, information can be similarly grouped into reports built from reception of this transmitted data. The ADS-B MASPS has defined State Vector reports for state vector data and other rapidly changing elements, and Mode Status reports for the relatively static elements. (Refer to Tables 3-1 and 3-2 in §3.3.1.1.) The ADS-B MASPS also defines On-Condition reports to support the transmission of specific operational mode data or data only needed for specific applications. While the TIS-B MASPS only has one encompassing TIS-B Target Report defined, the state vector data is a specific element of that report, for which specific update and quality characteristics can be attributed to it.

For brevity and clarity, the data exchange requirements found in this section refer to data as it is grouped in the three major types of reports specified in the ADS-B MASPS (i.e. Mode Status, State Vector, and On-Condition) and the messages used to support those reports.

Acquisition and Update Rate

For each Application Capability Level, the data link **shall** acquire all Mode Status and State Vector data for 95% of the observable user population at the farthest operational range specified by the Coverage requirement (#15) in Table 2-4 (§2.4.5). Report acquisition is defined as the reception of all report elements from a transmitting ASA participant required by the supported applications of the receiving ASA participant. <<Do we need to place requirements for on-condition messages here as well? We could say " . . . **shall** acquire all mode status, state vector, and application specific data for 95% . . .>>

Data pertaining to the operational status of a given aircraft (i.e. 24 bit address, aircraft capabilities, quality of broadcast data) are contained in Mode Status reports of ADS-B systems, is relatively static. Therefore, if the acquisition range requirement is met for this data, it can be assumed that the update rate for that data within the acquisition range will be sufficient. However, position and velocity data, contained in State Vector reports of ADS-B systems, is constantly changing. This data is the primary input for ASA applications and therefore requires that update rate requirements be placed on this data. For each Application Capability Level, the data link **shall** meet the most stringent requirements shown in Table 2-4 (§2.4.5) for Effective Update Rate (requirement #9) within the operational range specified by the Coverage requirement (#15) with 95% probability for 95% of the observable user population for all state vector <<??and application specific??>> data.

Data Accuracy and Latency

The operational range and safety criticality of an application are the two most significant factors in accuracy and latency requirements for that application. For each Application Capability Level, the data link **shall** meet the most stringent requirements specified for position, heading and velocity accuracy (#1-5) in Table 2-4 (§2.4.5). For each

Application Capability Level, the data link **shall** meet the latency requirements specified in Table 3.2-1.

Table 3.2-1: ADS-B Latency Requirements (in Seconds)

	ASA Application Capability Level			
Data Category	Basic	Intermediate	Future Advanced 1	Future Advanced 2
Target Identification	1.2 s	1.2 s	1.2 s	TBD
Target State Vector Data	1.2 s	1.2 s	0.4 sec	TBD
Special	1.2 s	TBD	TBD	TBD

Notes:

1. *Table 2-4 in §2.4.5 specifies the end-to-end ASA latency requirements. Table 3.2.1 shows the allocation of the total latency for the data link system.*

2. *The numbers found in Table 3.2-1 are taken from Appendix K of DO-242A.*

3.2.2.2 Data Link Network Capacity

Any data link system supporting air-to-air surveillance and ASA applications must be designed to accommodate expected future peak airborne traffic levels, as well as any airport surface units within range. The three traffic scenarios described below are taken from the summary published by the Technical Link Assessment Team (TLAT) in Appendix H of the Technical Link Assessment Report, March 2001 [ref. 4]. The March 2001 TLAT Report summarizes the technical assessment of ADS-B/situational awareness links commissioned by both the Safe Flight 21 (SF21) Steering Committee consistent with the recommendations of the RTCA Free Flight Select Committee and the Eurocontrol ADS Programme Steering Group (PSG). The March 2001 TLAT Report builds upon the November 1999, Phase One Report developed by a precursor to the TLAT, the SF21 Technical ADS-B Link Evaluation Team. Two of these scenarios represent expected future peak interference environments in the United States and Europe. These were developed to analyze link capacity for operational ranges of 40 nmi and less. The third scenario is a low density model used to analyze link capacity for ranges beyond 40 nmi. Figure 3.2.2.2-1 depicts the total traffic for each scenario as a function of range as the are numerically specified in Table 3.2.2.2-1.

Note 1: The numbers given in Table 3.2.2.2-1 are meant to be approximations of the number of aircraft and should not be interpreted as definitive quantities for these traffic scenarios.

Equipment supporting the Basic and Intermediate Application Capability Levels **shall** meet all performance requirements specified in Table 2-4 (§2.4.5) (requirements 8 through 15) for the high density traffic scenarios Core Europe 2015 (§3.2.2.1.1) and LA 2020 (§3.2.2.1.2), as defined below. Equipment supporting Advanced ASA Applications with an operational range of 40 nmi or less as specified by the Coverage requirement (#15) in Table 2-4 (§2.4.5) **shall** also meet all performance requirements specified in Table 2-4 (§2.4.5) (requirements 8 through 15) for the high density traffic scenarios Core

Europe 2015 (§3.2.2.1.1) and LA 2020 (§3.2.2.1.2), as defined below. Equipment supporting Advanced ASA Category Applications with an operational range beyond 40 nmi as specified by the Coverage requirement (#15) in Table 2-4 (§2.4.5) **shall** meet all performance requirements for those applications specified in Table 2-4 (requirements 8 through 15) for the low density traffic scenario (§3.2.2.1.3) defined below.

Note 2: *As operational concepts mature and applications are validated future versions of these MASPS may require Advanced ASA Applications with operational ranges beyond 40 nmi to meet performance requirements in the high density traffic scenarios at those extended ranges.*

Table 3.2.2.2-1: Number of airborne aircraft and range distributions.

	RANGE (nmi)							
	50	100	150	200	250	300	350	400
LA 99	175	350	525	700	883	1103	1362	1661
LA 2020	257	532	797	1071	1312	1655	2054	2469
Europe 2005	124	306	622	826				
Europe 2015	188	404	836	1348	1613	1942		
Low density	6	23	51	90	141	203	276	360

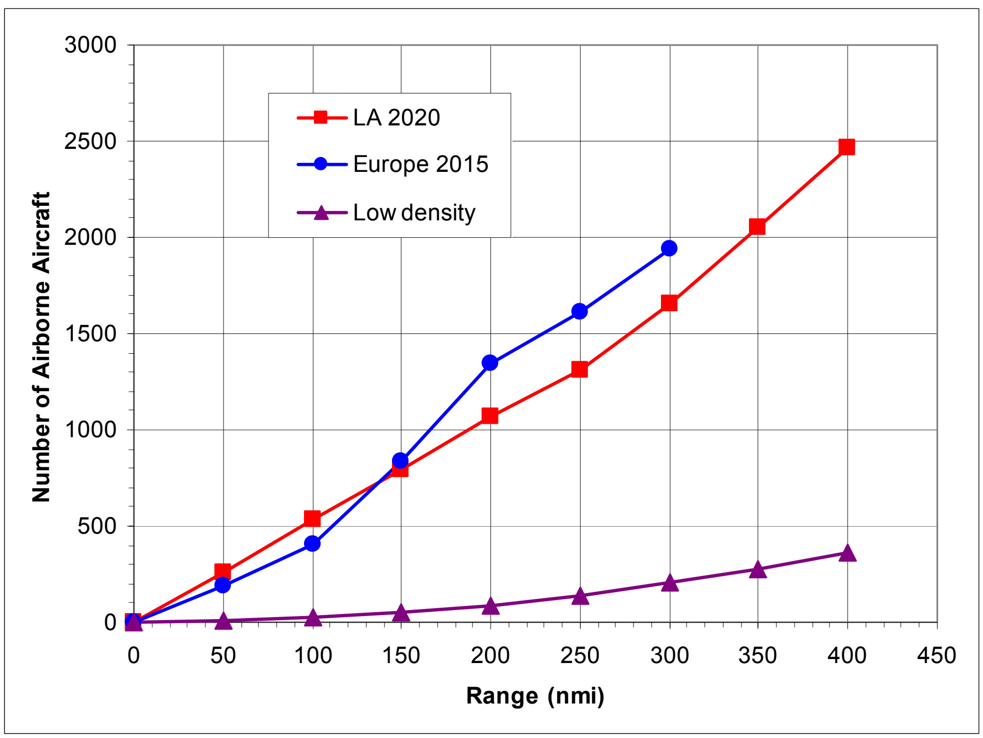

Figure 3.2.2.2-1: Cumulative Range Distributions of Traffic Scenarios

The two geographical areas which underlie the two high density scenarios discussed below (LA Basin and Core Europe) correspond to very different types of situations for an aircraft to operate in, and thus should provide two diverse environments for evaluation. The LA Basin scenario contains only about 14% of all airborne aircraft at altitudes above 10000 ft, while the Core Europe scenario has around 60% above 10000 ft. Thus, there will be vastly different numbers of aircraft in view for the two scenarios. Additionally, the aircraft density distributions are also quite different, which will place different stresses on the data link systems.

3.2.2.2.1 Core Europe 2015 Scenario

For the Core Europe 2015 scenario, the distributions and assumptions made were taken directly from the Eurocontrol document entitled "High-Density 2015 European Traffic Distributions for Simulation," dated August 17, 1999. [Add reference] This scenario is fairly well-defined and straightforward to apply.

This scenario includes a total of 2091 aircraft (both airborne and ground), and is based on the following assumptions:

- There are five major TMAs (Brussels, Amsterdam, London, Paris, and Frankfurt), each of which is characterized by:
  a. The inner region (12 nm radius) contains 29 aircraft at lower altitudes,
  b. The outer region (50 nm radius) contains 103 aircraft at mid to higher altitudes.
  c. There are assumed to be 25 aircraft on the ground, within a 5 nm radius, plus another 25 aircraft randomly distributed throughout the entire scenario area.
- These aircraft are assumed to be symmetrically distributed rotationally, and the aircraft in an altitude band are assumed to be uniformly distributed throughout the band. However, all aircraft in the same band are assumed to be traveling at the same band-dependent velocity.
- Superimposed over these aircraft is a set of airborne en route aircraft, which are distributed over a circle of radius 300 nm. These aircraft are distributed over four altitude bands, ranging from low to upper altitudes. They also travel at velocities which are altitude band dependent.
- All aircraft are assumed to be ADS-B equipped. All aircraft above 10000 feet are assumed to be either ADS-B MASPS equipage class A3 (75%) or A2 (25%), while below 10000 feet, the ratios are adjusted to give the entire ensemble of aircraft the following proportions of equipage:
  a. 30 % A3
  b. 30% A2
  c. 30% A1
  d. 10% A0

  Note: *Aircraft equipage is assigned according to altitude. The lower percentages of A0 and A1 aircraft than those found in the LA Basin scenarios reflect differences in operating conditions and rules in European airspace.*

3.2.2.2.2 LA 2020 Scenario

This scenario was based on the LA Basin 1999 maximum estimate. It was assumed that air traffic in this area would increase by a few percent each year until 2020, when it would be 50 % higher than in 1999.

The following assumptions went into generating the airborne and ground aircraft for the LA Basin 2020 scenario:

- The density of airborne aircraft was taken to be:

  a. Constant in range from the center of the area out to 225 nautical miles (5.25 aircraft/nm), (i.e., the inner circle of radius one nm would contain approximately five aircraft, as would the ring from 224 to 225 nm) and
  b. Constant in area from 225 nm to 400 nm (.00375 aircraft/nm^2).

- There were assumed to be a fixed number of aircraft on the ground (within a circle of radius 5 nm at each airport), divided among LAX, San Diego, Long Beach, and five other small airports. Half of the aircraft at each airport were assumed to be moving at 15 knots, while the other half were stationary. The approximate cumulative distribution of these aircraft on the ground from the center point of the area is as follows:

  a. 143 within 50 nmi
  b. 190 within 100 nmi
  c. 225 beyond 150 nmi

- The altitude distribution of the airborne aircraft was assumed to be exponential, with a mean altitude of 5500 feet. This distribution was assumed to apply over the entire area.

  Note: *The TLAT LA2020 traffic scenario did not account for local terrain as it assumed a smooth earth model. For improved fidelity, adjustment off the aircraft altitudes in the traffic scenarios appropriate when used in conjunction with a link performance model that includes terrain.*

- The airborne aircraft were assumed to have the following average velocities, determined by their altitude. The aircraft velocities for aircraft below 25000 feet will be uniformly distributed over a band of average velocity +/- 30 percent.

  a. 0-3000 feet altitude 130 knots
  b. 3000-10000 ft 200 knots
  c. 10000-25000 ft 300 knots
  d. 25000-up 450 knots

- The aircraft are all assumed to be moving in random directions.

- As with Core Europe 2015, all aircraft above 10000 feet are assumed to be either ADS-B MASPS equipage class A3 (75%) or A2 (25%), however, for LA2020, the ratios are adjusted to give the entire ensemble of aircraft the following proportions of equipage below 10000 feet:

  a. A3 30%
  b. A2 10%
  c. A1 40%
  d. A0 20%

The scenario for the 2020 high density LA Basin case contained a total of 2694 aircraft: 1180 within the core area of 225 nm, 1289 between 225-400 nm, and 225 on the ground. This represents a scaling of the estimated maximum 1999 LA Basin levels upward by 50 percent. Of these aircraft, 471 lie within 60 nm of the center. (This includes aircraft on the ground.) Around ten percent of the total number of aircraft are above 10000 ft in altitude, and more than half of the aircraft are located in the outer (non-core) area of the scenario.

An attempt was made to at least partially account for the expected lower aircraft density over the ocean. In the third quadrant (between 180 degrees and 270 degrees), for distances greater than 100 nm from the center of the scenario, the density of aircraft was reduced to 25 % of the nominal value used. The other 75 % of aircraft which would have been placed in this area were distributed uniformly among the other three quadrants at the same range from the center. This results in relative densities of 1:5 between the third quadrant and the others.

3.2.2.2.3 Low Density Scenario

For simplicity, the number of aircraft for the third scenario was set by scaling the current maximum LA Basin levels downward by a factor of five, amounting to 360 total aircraft. These aircraft are uniformly distributed in the horizontal plane within a circle of 400 nautical miles. In the vertical direction, they are distributed uniformly between 25,000 feet and 37,000 feet. The velocities are all set to 450 knots and are randomly distributed in azimuth. All of the aircraft are assumed to be A3 equipped.

3.2.3 System Specific Requirements

3.2.3.1 ADS-B (Do we need ADS-B specific section?)

Add ADS-B data link requirements here.

3.2.3.2 TIS-B (Do we need TIS-B specific section?)

Add ADS-B data link requirements here.

3.3 ASA Receiving Participant Subsystems

ASA receive subsystems include the ADS-B/TIS-B Receiver, (treated in §3.3.1), Airborne Surveillance and Separation Assurance Processing (ASSAP, treated in §3.3.2), and the Cockpit Display of Traffic Information (CDTI, treated in §3.3.3). Each of these three subsections is further broken into functional, performance, and interface requirements, e.g., §3.3.1.1 describes functional requirements for the ADS-B receiver, §3.3.1.2 specifies performance requirements for the receiver, and §3.3.1.3 specifies interface requirements for the ADS-B receiver. Note that to avoid repetition, all interface requirements are specified as interfaces *to* a particular subsystem.

3.3.1 ADS-B/TIS-B Receiver Requirements

3.3.1.1 ADS-B/TIS-B Receiver Subsystem Functional Requirements

The ADS-B/TIS-B receiver is expected to receive the appropriate link specific signal in space, detect and/or correct bit errors as appropriate, and conduct appropriate link specific monitoring functions.

The ADS-B / TIS-B receiver **shall** receive link dependent messages from all ADS-B / TIS-B transmit subsystems within range as per §3.2, and **shall** assemble ADS-B and TIS-B reports, including the State Vector Report (Table 3-1) and the Mode Status Report (Table 3-2). The appropriate ADS-B report **shall** be updated and made available to ASSAP each time any new (changed) information is received for an A/V across the ADS-B / TIS-B link.

Table 3-1: Surveillance State Vector Report

	SV Elem. #	Contents	Required from airborne participants	Required from surface participants	Reference Section
ID	1	Participant Address	•	•	
	2	Address Qualifier	•	•	
TOA	3	Time Of Applicability	•	•	
Geometric Position	4a	Latitude (WGS-84)	•	•	
	4b	Longitude (WGS-84)	•	•	
	4c	Horizontal Position Valid	•	•	
	5a	Geometric Altitude	•		
	5b	Geometric Altitude Valid	•		
Horizontal Velocity	6a	North Velocity while airborne	•		
	6b	East Velocity while airborne	•		
	6c	Airborne Horizontal Velocity Valid	•		
	7a	Ground Speed while on the surface		•	
	7b	Surface Ground Speed Valid		•	
Heading	8a	Heading while on the Surface		•	
	8b	Heading Valid		•	
Baro Altitude	9a	Pressure Altitude	•		
	9b	Pressure Altitude Valid	•		
Vertical Rate	10a	Vertical Rate (Baro/Geo)	•		
	10b	Vertical Rate Valid	•		
NIC	11	Navigation Integrity Category	•	•	

Table 3-8: Mode-Status (MS) Report Definition.

	MS Elem. #	Contents	Reference Section
ID	1	Participant Address	
	2	Address Qualifier	
TOA	3	Time of Applicability	
Version	4	ADS-B Version Number	
ID, Continued	5a	Call sign	
	5b	Emitter Category	
	5c	A/V Length and Width Codes	
Status	6a	Mode Status Data Available	
	6b	Emergency/Priority Status	
CC, Capability Codes	7	Capability Class Codes	
		7a: TCAS/ACAS installed and operational 7b: CDTI display capability 7c: (Reserved for Service Level) 7d: ARV report Capability Flag 7e: TS report Capability Flag 7f: TC report Capability Level 7g: Reporting ADS-B Reference Position (CC Codes reserved for future growth)	
OM, Operational Mode	8	Operational Mode Parameters	
		8a: TCAS/ACAS resolution advisory active 8b: IDENT Switch Active 8c: Receiving ATC services (Reserved for future growth)	
SV Quality	9a	Nav. Acc. Category for Position (NAC_P)	
	9b	Nav Acc. Category for Velocity (NAC_V)	
	9c	Surveillance Integrity Level (SIL)	
	9d	Barometric Altitude Quality (BAQ)	
	9e	NIC_{baro} - Altitude Cross Checking Flag	
Data Reference	10a	True/Magnetic Heading	
	10b	Vertical Rate Type (Baro./Geo.)	
Other	11	Reserved for Flight Mode Specific Data	

3.3.1.1.1 Future: Additional requirements for Advanced 2 ASA Systems

Advanced ASA 2 systems **will** potentially require additional data for the approach spacing application. In particular, transmission of plan data consisting of a vector of planned speed reduction ranges and planned speeds are necessary.

Note: These reports will be defined in a later revision of this MASPS.

3.3.1.2 ADS-B/TIS-B Receiver Subsystem Performance Requirements

Data latencies and accuracies are specified in §3.2 for the ADS-B system as a whole (including the ADS-B transmitter and the receiver).

The availability risk, continuity risk, and integrity risk requirements of Table 3-2 **shall** be met by the ADS-B/TIS-B receiver subsystem.

Definitions of subsystem integrity, availability, and continuity are provided below.

Table 3-2: ADS-B / TIS-B Receiver Availability Risk, Continuity Risk, and Integrity Risk Requirements (Failure rate per flight hour)

	Application Capability Level			
Feature	**Basic**	**Intermediate**	**E.g., Advanced 1**	**E.g., Advanced 2**
Subsystem Availability Risk	10^{-3}	10^{-3}	10^{-4}	10^{-4}
Subsystem Continuity Risk	10^{-3}	10^{-4}	10^{-4}	10^{-4}
Subsystem Integrity Risk	10^{-3}	10^{-3}	10^{-5}	10^{-5}

3.3.1.3 Interface Requirements to the ADS-B/TIS-B Receiver Subsystem

There are no interfaces to the ADS-B/TIS-B receiver from within ASA that are specified within this MASPS. ADS-B messages interface between the transmitting ship's ADS-B transmitter and the receiving ship's ADS-B/TIS-B receiver. These messages are data link dependent and are specified in the appropriate link dependent ADS-B MOPS.

3.3.2 Airborne Surveillance and Separation Assurance Processing (ASSAP) Subsystem Requirements

ASSAP is the surveillance and separation assurance processing component of ASA. ASSAP processes incoming data from other aircraft/vehicles and derives information for display on the CDTI, as well as alerting and guidance information that will also be displayed. Flight crew command and control inputs that affect application functions are also processed by ASSAP. ASSAP consists of three sub-functions, as illustrated in Figure 3.3.-1:

1. A surveillance processing sub-function that integrates surveillance data from multiple sources, establishes tracks, and determines the surveillance quality of targets.
2. A function to process coupled applications – deriving specific alert and guidance information to provide to the flight crews
3. A function to process background applications, deriving required alerts and guidance for conflict detection and airborne conflict management.

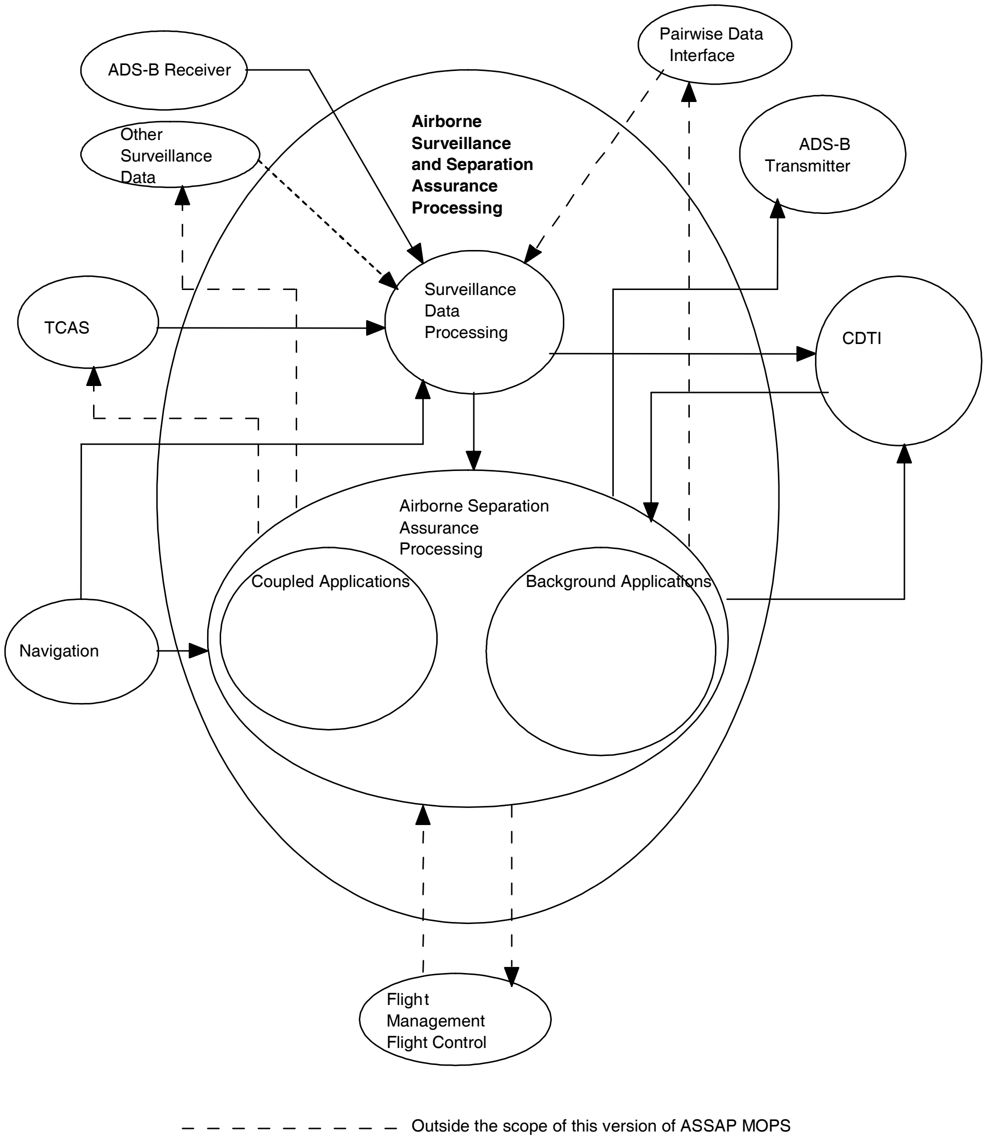

Figure 3.3-1. ASSAP Components

3.3.2.1 ASSAP Functional Requirements

ASSAP functional requirements are broken into surveillance processing requirements (§3.3.2.1.1) and applications processing requirements (§3.3.2.1.2).

3.3.2.1.1 ASSAP Surveillance Processing Requirements

The ASSAP surveillance processing as described below is required for all Application Capability Levels.

ASSAP surveillance processing function receives information for target A/V's from various surveillance sources, correlates the data, registers the data, and outputs a track file consisting of state and other information about each A/V under track. Requirements for the surveillance sub-function follow.

1. ASSAP **shall** provide a tracking function. The tracking function:

   a. **Shall** maintain, for each A/V under track, a file that contains, at a minimum, the elements listed in Table 3-4.

Transmit Quality Level	Application Capability Level	Notes
e.g., 0, 1	Basic	EV Acquisition only
e.g., 2	Basic	Enables CD processing
e.g., 3	Basic	Enables ASSA processing
e.g., 4	Intermediate	
e.g., 5	Advanced 1	

NOTE: ABOVE TABLE IS TENTATIVE UNTIL TRANSMIT QUALITY LEVELS ARE FINALIZED

   b. **Shall** determine all fields in Table 3-4 that are not directly provided in measurements. The *last measurement* data fields indicated in Table 3-4 are intended include variables that were obtained with the last valid measurement received for the track.

   c. **Shall** include a correlation function that associates target data from different surveillance sources that relate to the same aircraft/vehicle track, i.e., the correlation function **shall** associate and cross-reference target data from ADS-B targets, TIS-B targets, and TCAS targets. The correlation function **shall** continually monitor and update target cross references as necessary.

   d. **Shall** include a registration bias estimation function that estimates systematic biases between surveillance sensors providing reports on each a/v.

   e. **Shall** include a registration correction function that registers measurements (including time, position, and velocity) from different surveillance sources.

   f. **Shall** include an estimation function that estimates track state based on one or more surveillance source inputs. Track state includes time of the state estimate, horizontal position, horizontal velocity, altitude, altitude rate, heading (if possible), and track quality, including accuracy, integrity containment boundary, and integrity containment risk (see §2.4.5).

      The estimation function may combine information from different data sources in order to improve the track state estimate. ASSAP surveillance processing **shall** not degrade the quality (accuracy, integrity containment bound, or integrity containment risk) of the data it receives from any single surveillance source, but may enhance the quality of the track information, using techniques such as Kalman filters. ASSAP **shall** estimate the quality of the track state information that is maintained in the track file, and maintain quality measures for the track state information, as indicated in Table 3-3.

   g. **Shall** initiate a track for each observed A/V when sufficient measurement information is received to form a minimum track state. Required minimum measurement elements are noted in Table 3-3.

   h. **Shall** terminate a track when the maximum coast interval (Table 2-4, row 16) has been exceeded for all of the applications for which the track is potentially being used.

2. Correlation of TCAS data: If TCAS data is to be integrated on the CDTI, ASSAP **shall** correlate the TCAS tracks with its internal tracks to the extent practicable. For correlated TCAS tracks ASSAP **shall** recognize if a track has an active TCAS resolution advisory or traffic advisory, and **shall** provide that information in the track file (see Table 3-4).

3. TIS-B / ADS-B correlation: while it is normally expected that TIS-B and ADS-B information (on a given link) will be mutually exclusive, the possibility exists that an ASA participant will receive TIS-B and ADS-B information on the same aircraft. Therefore, ASSAP surveillance processing **shall** cross-correlate the targets from TIS-B and ADS-B reports supplied by the ADS-B receiver. The correlation should make use of all available data that can assist in this process from the state vector and other reports.

4. ADS-B / ADS-B correlation: if the aircraft ADS-B installation includes multiple ADS-B links, ASSAP surveillance processing **shall** correlate (cross-reference) targets from the different links and associate the targets with the appropriate ASSAP track.

5. For transmit only A/Vs ASSAP surveillance processing **shall** determine target qualification for ASA level based on transmit quality level. Table 3-3 indicates the appropriate application capability levels as a function of transmit quality level.

6. ASSAP **shall** extrapolate target state position information to the current time at the interface with the CDTI with at least a 1 Hz rate.

Table 3-3. Mapping of Transmit Quality Levels to Application Capability Level

Transmit Quality Level	Application Capability Level	Notes
e.g., 0, 1	Basic	EV Acquisition only
e.g., 2	Basic	Enables CD processing
e.g., 3	Basic	Enables ASSA processing
e.g., 4	Intermediate	
e.g., 5	Advanced 1	

NOTE: ABOVE TABLE IS TENTATIVE UNTIL TRANSMIT QUALITY LEVELS ARE FINALIZED

Table 3-4. Elements of the ASSAP track file for an individual track

Category	Content	Minimum Track Measur-ement Element s 3.3.2.1.1 g	Measured Data	ASSAP Derived Data	Reference Section
ID	Participant Address	X	X		3.1…
	Address Qualifier		X		3.1…
	Call Sign		X		3.1…
Last Measurement Data	Time of applicability -- measurement	X	X		3.1…
	Latitude (WGS-84)	X	X		3.1…
	Longitude (WGS-84)	X	X		3.1…
	Geometric Altitude	X	X		3.1…
	Geometric Altitude Valid	X	X		3.1…
	Pressure Altitude	X	X		3.1…
	North Velocity	X	X[1]		3.1…
	East Velocity	X	X[1]		
	Pressure Altitude	X	X		3.1…
	Vertical Rate (Baro/Geo)	X	X		3.1…
	Vertical Rate Type (Baro / Geo)	X	X		3.1…
Last Measurement Data Quality	Horizontal integrity containment bound	X	X		3.1…
	Horizontal integrity containment risk	X	X		3.1…
	95% horizontal position accuracy	X	X		3.1…
	95% horizontal velocity accuracy	X	X		3.1…
	Geometric altitude containment bound	X	X		3.1…
	Geometric altitude containment risk		X		
	Barometric Altitude Quality (BAQ)	X	X		3.1…
	Barometric Altitude Integrity	X	X		3.1…
State Vector Estimate (§3.3.2.1.1)	Time of SV estimate			X	(§3.3.2.1.1)
	Latitude (WGS-84)			X	3.1…
	Longitude (WGS-84)			X	3.1..
	Geometric Altitude			X	3.1..
	Geometric Altitude Valid			X	3.1..
	Pressure Altitude			X	3.1..
	North Velocity			X	3.1..
	East Velocity			X	3.1..
	Pressure Altitude			X	3.1..
	Vertical Rate (Baro/Geo)			X	3.1..
	Vertical Rate Type (Baro / Geo)			X	3.1..
State Vector Estimate Quality (§3.3.2.1.1)	Horizontal integrity containment bound			X	3.1..
	Horizontal integrity containment risk			X	3.1..
	horizontal position accuracy			X	3.1..
	horizontal velocity accuracy			X	3.1..
	Geometric altitude containment bound			X	3.1..
	Geometric altitude containment risk			X	3.1..
	Barometric Altitude Quality (BAQ)			X	3.1…
	Barometric Altitude Integrity			X	3.1…
Other	Emitter Category		X		3.1…

	A/V Length and Width Codes		X		3.1…
	Emergency / Priority Status		X		3.1…
	Application capability level	X	X [2]	X [2]	2.3..
	Transmit quality level	X	X		3.1..
TCAS	Correlated TCAS Track ID				
	TCAS RA Active				
	TCAS TA Active				

Notes:

1. *On the surface, heading and ground speed must be converted to Cartesian coordinates.*
2. *For transmit-only A/V's application capability must be derived from transmit quality level. See Table 3-3.*

3.3.2.1.1.1 Definitions

This section contains definitions of terms used above.

Track: A sequence of measurements and state information relating to a particular aircraft or vehicle.

Track State: The basic kinematic variables that define the state of the aircraft or vehicle of a track, e.g., position, velocity, acceleration.

Covariance: A two dimensional symmetric matrix representing the uncertainty in a track's state. The diagonal entries represent the variance of each state; the off-diagonal terms represent the covariances of the track state.

Registration: The process of aligning measurements from different sensors by removing systematic biases.

Correlation: The process of determining that a new measurement belongs to an existing track.

Estimation: The process of determining a track's state based on new measurement information

Extrapolation**:** The process of moving a track's state forward in time based on the track's last estimated kinematic state.

3.3.2.1.2 ASSAP Applications Processing Requirements

ASSAP **shall** make *ASSAP track reports* available to the CDTI for all active applications.

Note: Precise conditions under which airborne and surface targets are to be displayed and filtered is to be developed in the ASSAP/CDTI MOPS. See section 3.3.3 for filtering requirements on the CDTI.

ASSAP track reports elements are listed in Table 3-5.

Table 3-5. ASSAP track report elements

Category	Contents	Reference Section	Notes
Identity	Call Sign	3.1…	
State Vector Estimate	Time of SV estimate	§3.3.2.1.1 bullet 1f	
	Range relative to own ship	§3.3.2.1.2	
	Bearing relative to own ship	§3.3.2.1.2	
	Geometric Altitude	3.1…	
	Pressure Altitude	3.1…	
	North Velocity	3.1…	
	East Velocity	3.1…	
	Vertical Rate (Baro/Geo)	3.1…	
	Vertical Rate Type (Baro / Geo)	3.1…	
	Barometric Altitude Integrity	3.1…	
Alerts	CAZ Alert		
	CDZ Alert		
Status	Emitter Category	3.1…	
	A/V Length and Width Codes	3.1…	
	Emergency / Priority Status	3.1…	
	Supported applications	§3.3.2.1.2	
TCAS	TCAS RA Active		
	TCAS TA Active		
Guidance (Examples for future advanced application capability levels)	Break-out		Advanced 2 (ICSPA)
	Commanded speed		Advanced 2 (ASIA)
	Conflict Resolution Advisory		Advanced 1 (ACM)

Range, Bearing Relative to Own Ship

The range and bearing of the track relative to own ship shall be computed by applying the appropriate coordinate transformations between the track's latitude and longitude and own ship's latitude and longitude and the display coordinates, and converting the result into polar (range, bearing) coordinates.

Supported Application

Supported application shall indicate the application capability level, indicate any optional applications that are being processed for the track (i.e., CD, ASSA, FAROA), and shall indicate if the data is considered to be degraded for a given application.

3.3.2.1.2.1 Basic ASA

ASSAP track quality (§3.3.2.1.1) **shall** be compared with acceptable values for basic applications, as per Table 2-4. Specifically, the following data attributes shall be assessed for each track:

track state data accuracy

track state data integrity

Update interval

Note that if the track is being surveilled by multiple sources, the determination of acceptability for applications should be based on the track quality as derived by ASSAP, rather than on quality of any individual source.

The ASSAP track report **shall** be updated to reflect any degraded condition for EV acquisition or ASSA, as appropriate, as per table 2-4. The ASSAP track report **shall** indicate if the track's quality is insufficient for a basic application.

If the installed system has the option for conflict detection (CD), ASSAP **shall** determine if each track is eligible for CD processing, as per Table 2-4. Each track that is eligible for CD **shall** be processed by the CD alerting function, and CAZ alerts or CDZ alerts **shall** be issued as appropriate. ASSAP **shall** include in the ASSAP track report the status of the CAZ alert and the CDZ alert.

3.3.2.1.2.2 Intermediate ASA

There are no specific additional application processing requirements for intermediate ASA.

3.3.2.1.2.3 Advanced ASA

ASSAP **will** process ASIA, ACM, and ICSPA applications based on future algorithms to be determined. For the ACM application, ASSAP will issue appropriate advisory information to the CDTI. For the ASIA application, ASSAP will derive speed guidance. For the ICSPA application, ASSAP will provide path and break-out alerts as required. See the appropriate application appendix for more information on these applications.

3.3.2.2 ASSAP Performance Requirements

General requirements for ASSAP are as follows:

1. ASSAP **shall** introduce a data latency of no more than 200 mS between the time data is received from the surveillance source (ADS-B/TIS-B receiver, TCAS) at the ASSAP interface and the time that the data is presented to the CDTI interface.

   (<u>Ed Note:</u> may split requirement between surveillance data outputs and outputs derived from applications processing, e.g., alerts vs. position, may be a delay in issuing the alert vs displaying the position.)

2. ASSAP shall achieve the subsystem integrity risk, continuity risk, and availability risk requirements listed in Table 3-4.

Table 3-4: ASSAP Availability, Continuity, and Integrity Requirements (Failure rate per flight hour or operation)

	Application Capability Level			
Feature	**Basic**	**Intermediate**	**E.g., Advanced 1**	**E.g., Advanced 2**
Subsystem Availability Risk	10^{-3}	10^{-3}	10^{-4}	10^{-4}
Subsystem Continuity Risk	10^{-3}	10^{-4}	10^{-4}	10^{-4}
Subsystem Integrity Risk	10^{-3}	10^{-3}	10^{-5}	10^{-5}

Note N/R = No Requirement

3.3.2.3 ASSAP Interface Requirements

ASSAP provides the central processing for ASA, and interfaces with many other avionics subsystems. Table 3.3-8 indicates the required data interfaces to ASSP. All data indicated by a dot (•) **shall** be provided to the ASSAP function, with the exception of those items labeled "future." All data in Table 3.3-8 indicated by the letter "d" are optional, desired, interfaces.

Each data item listed in the table is described in detail below.

Note: *Some of these data item names are re-used in subsequent requirements tables; the definitions will not be repeated for items with identical names and definitions.*

Table . **3.3-8** Interfaces to ASSAP

Source	Info Category	Information Element	ASA Level			
			Basic		Intermediate	Advanced
			Airborne	ASSA & FAROA		
ADS-B / TIS-B Receiver	Target ID	Call Sign	d	d	•	•
		Address	•	•	•	•
		Category	d	d	d	•
		A/V length and width codes		•		
	Target State Data	Time of applicability (TOA)	•	•	•	•
		Horizontal Position	•	•	•	•
		Horizontal Velocity	•	•	•	•
		Altitude	•	•	•	•
		Altitude Rate	•	•	•	•
		Heading		•		
	Target Quality	NIC	•	•	•	•
		SIL	•	•	•	•
		NAC_P	•	•	•	•
		NAC_v	•	•	•	•
	Special	Future: Planned Final Approach Speed				•
TCAS	TCAS related data (note 1)	RA Active	•		•	•
		TA Active	•		•	•
		Range	•		•	•
		Bearing	•		•	•
		Altitude (Mode C Code) (note 2)	•		•	•
		TCAS altitude rate (note 3)	•		•	•
		Mode S Address (note 2)	•		•	•
		TCAS Track ID (2)	•		•	•

Source	Info Category	Information Element	ASA Level			
			Basic		Intermediate	Advanced
			Airborne	ASSA & FAROA		
Navigation	Own ship state data	TOA	•	•	•	•
		Horizontal Position	•	•	•	•
		Horizontal Velocity	•	•	•	•
		Altitude	•	•	•	•
		Vertical Rate	•	•	•	•
		Heading	•	•	•	•
	Ownship quality	Integrity containment radius	•	•	•	•
		Integrity containment probability	•	•	•	•
		Horizontal Position Accuracy	•	•	•	•
		Horizontal Velocity Accuracy	•	•	•	•
CDTI	Flight Crew Inputs	Selected coupled application			•	•
		Selected target			•	•
		Alert zone selection			•	•
		Future: Own ship Planned final approach speed				•
?	Ownship ID	Future: Category				•

• = Required; d = desired

Notes:

1. *Required if TCAS is present in the configuration and an integrated TCAS/ASA traffic display is used.*
2. *This information requires a change to the standard TCAS bus outputs defined in ARINC 735A which currently does not provide the Mode S and Mode A address codes, nor does it necessarily output Mode C.*
3. *For display of up/down arrow if there is no ADS-B track that correlates with the TCAS track.*

3.3.2.3.1 Interfaces to ASSAP from the ADS-B/TIS-B Receiver

3.3.2.3.1.1 Target Identification

The basic identification information to be conveyed to ASSAP includes the following elements: call sign, address, category, and A/V length and width codes. The definitions for these data items are as per §3.3.1

3.3.2.3.1.1.1 Time of Applicability (TOA)

Time of Applicability (TOA) is associated with each state report for the target or for own-ship. TOA indicates the time at which the reported state values were valid. TOA shall be reported to ASSAP for target state data and for own-ship state data.

3.3.2.3.1.1.2 Horizontal Position

Horizontal position reported to ASSAP shall consist of latitude and longitude referenced to the WGS-84 ellipsoid. The definition of horizontal position is as per §3.3.1 Horizontal Velocity

Horizontal velocity shall be reported to ASSAP in north-south and east-west coordinates relative to the WGS-84 coordinate system as per definitions in §3.3.1.

3.3.2.3.1.1.3 Altitude

Both target barometric pressure altitude and geometric shall be provided, if available, to ASSAP. If the target is on the airport surface no altitude is required but an indication shall be provided to ASSAP. Barometric and geometric altitudes are as defined in §3.3.1.

3.3.2.3.1.1.4 Vertical Rate

Target altitude rate is as defined in §3.3.1.

Heading

Heading is as defined in §3.3.1. An indication shall be provided to ASSAP as to whether the heading is measured from true north or magnetic north. Note that heading is required for surface applications only.

3.3.2.3.1.2 Target Quality

Target quality as communicated from surveillance systems shall consist of Navigation integrity category for position (NIC), Surveillance Integrity Level (SIL), navigation accuracy category for position (NAC_P), navigation accuracy category for velocity (NAC_V), and indications of barometric altitude quality as defined in §3.3.1 through §3.3.1.

3.3.2.3.1.3 Future: Special Data

Planned final approach speed will need to be communicated to ASSAP from both own-ship and the lead-ship if the ASIA application is implemented. Planned final approach speed is the speed input to the ASIA application for the lead ship, and is an indicated airspeed.

3.3.2.3.2 Interfaces to ASSAP from TCAS

Future ASA systems will require TCAS RA information to support the ACM application.

For initial ASA applications, TCAS data is needed specifically to support configurations with integrated ASA / TCAS traffic displays[1]. For these configurations the data items in the following subparagraphs shall be provided to ASSAP for each TCAS track that is to be displayed. These items are required to allow the correlation of TCAS tracks with ASA tracks for traffic display integration, and these items also allow the display of an indication of an active Resolution Advisory (RA), or Traffic Advisory (TA).

3.3.2.3.2.1 RA Active

Indicates that a Resolution Advisory is currently in progress for the track.

3.3.2.3.2.2 TA Active

Indicates that a Traffic Advisory is currently in progress for the track.

3.3.2.3.2.3 Range

The range of the TCAS track from own-ship.

3.3.2.3.2.4 Bearing

The bearing of the TCAS track from ownship relative to the ship's heading.

3.3.2.3.2.5 Altitude

The barometric altitude of the track as reported by TCAS.

3.3.2.3.2.6 Altitude Rate

3.3.2.3.2.7 Mode S Address

The mode S address of the TCAS track.

3.3.2.3.2.8 TCAS Track ID

The internal track ID of the TCAS track.

3.3.2.3.3 Interfaces to ASSAP from Own-ship Navigation

3.3.2.3.3.1 Own-ship State Data

Own ship state data is defined identically to that of the target ship state data, as per §3.3.1.

[1] This display is sometimes termed the "TA" display.

3.3.2.3.3.2 Own Ship Quality

Own ship quality is very similar to target ship quality; however, as the information comes directly from the navigation system it is not yet categorized into NIC, NAC, and SIL values.

An integrity containment radius for position and associated no-alarm probability are assumed to be available from the navigation system. A 95% accuracy bound on both position and velocity are also assumed to be available. ASSAP shall provision for the acceptance of these parameters.

3.3.2.3.4 Flight Crew Inputs

A flight crew input may be required to display desired target parameters. For certain applications, the flight crew must select a specific target.

3.3.2.3.4.1 Selected Coupled Application

This is an indication of the application that is being run. Coupled applications include Enhanced visual approach, ASIA, and CSPA.

3.3.2.3.4.2 Selected Target

A selected target is a target for which a coupled application is to be conducted.

3.3.2.3.4.3 Alert Zone Selection

The alert zone specifies the horizontal and vertical criteria for a CD alert or ACM alert and resolution.

3.3.2.3.4.4 Future: Own-ship planned final approach speed

3.3.2.3.5 Future: Own-Ship ID

Own ship ID includes own-ship category that is needed for supporting the ASIA application. Both own-ship and lead-ship categories are needed to determine wake vortex separation minimums.

3.3.3 CDTI Subsystem Requirements

Editor's Note: For this version of Chapter 3 (May 14, 2003), the CDTI requirements have been removed. This is due to the massive reworking of material found here previously as much of the material was deemed t be "MOPS Level" and will be laced in an appendix of the initial ASA MASPS and carried over into the CDTI MOPS. Further, the draft CDTI requirement are to be reviewed by a joint WG1/WG4 breakout session at the May WG4 meeting in Seattle. Therefore, the draft CDTI material will be kept separate until after the Seattle WG4 meeting. Please refer to the WG4 page on the web site and the "Meeting materials" file for Seattle to obtain the draft CDTI material.

3.4 External Subsystems

Subsystems external to ASA include navigation, TCAS, flight management and flight controls, etc.

The ASA MASPS does not specify requirements on these subsystems, but assumptions regarding external subsystem performance are listed.

3.4.1 Navigation

The navigation subsystem is assumed to produce the following values:

- State data (§ **Error! Reference source not found.**)
- Time of applicability (§ **Error! Reference source not found.**)
- Horizontal Position (§ **Error! Reference source not found.**)
- Horizontal Velocity (§ **Error! Reference source not found.**)
- Altitude (§ **Error! Reference source not found.**)
- Altitude rate (§ **Error! Reference source not found.**)
- Surface / airborne indication (§)
- Heading (§ **Error! Reference source not found.**)
- Navigation information quality (§ **Error! Reference source not found.**)

3.4.2 TCAS

<<add requirements here>>

3.4.3 Airport Surface Maps

<<add requirements here>>

3.4.4 Flight Management System

<<add requirements here>>

3.4.5 Flight Control System

<<add requirements here>>

3.4.6 FIS-B / Weather

<<add requirements here>>

3.4.7 Terrain

<<add requirements here>>

3.4.8 Addressed Data Link

<<add requirements here>>

3.4.9 ADS-Contract

<<add requirements here>>